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ABSTRACT

Four studies were conducted in which subjects performed three sets of tasks tapping, in a standard format, progressively refined, non-linguistic processes in speech processing. The studies examined the following: (1) auditory versus phonetic processes in the discrimination of consonants; (2) auditory versus phonetic processes in loudness and pitch judgments; (3) auditory versus phonetic processes in the categorization of consonants; and (4) phonetic processes in the categorization of consonants. Subjects were male and female Canadian francophones of different ages and varying degrees of knowledge of English. The third study gave the clearest results, allowing dichotomization into two separate processes by finding differential patterns of development for two tasks. It was possible to postulate that the processes were linguistic and non-linguistic by finding the expected specific patterns of development, specific patterns of sex by age similarities and differences, differential patterns of correlation between degree of bilingualism and consonant contrasts, and, unexpectedly, a different pattern of performance on one contrast, all according to task. Results are discussed mainly in relation to other experiments on the phonetic mode. A 90-item bibliography and substantial appended materials concerning the design and results of the studies are included. (Author/MSE)

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SPEECH AND LANGUAGE LEARNING: NON-LINGUISTIC VERSUS LINGUISTIC PROCESSES

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Joe Scanella, Alouettes head coach: "Vince will make it because he's bright. I've never known a brighter, harder-working quarterback. He's so bright it scares me. I'll tell you how bright he is. We have these two terms, 'flip' and 'flop'. Flip means two inside guys line up on opposite sides, and flop means two outside guys do it. Know how Vince figured it out? He said flip has an 'i' in it for inside and flop has an 'o' for outside. He's very conceptual."

(About Vince Ferragamo, in ***The Gazette****, September 12, 1981)*

Abstract

Four studies were conducted in which three sets of tasks were devised which tapped in a standard format, progressively refined, non-linguistic versus linguistic processes in speech processing. The third set of tasks gave the clearest results. In it, male and female francophone subjects of different ages and of varying degree of knowledge of English were tested. Three sets of consonant contrasts were used. A dichotomization into two separate processes was possible by finding expected differential patterns of development for the two tasks; we were able to postulate that the two processes were non-linguistic versus linguistic by finding expected specific patterns of development, specific patterns of sex by age similarities and differences, differential patterns of correlations between degree of bilingualism and consonant contrasts, and unexpectedly a different pattern of performance on one contrast, all according to task. The results are discussed mainly in relation to other experiments on "the phonetic mode".

Résumé

Le travail qui suit comprend quatre études dans lesquelles nous nous sommes attaquées au sujet de la dichotomie qu'on prétend exister entre ce qu'on appelle processus linguistiques et ce qu'on appelle processus non-linguistiques dans la perception des sons. Nous avons essayé de démontrer l'existence de ces deux processus en partant d'une approche de base que nous avons progressivement raffinée. Ce sont les deux dernières études qui nous ont donné les résultats les plus probants. En effet, conformément à nos hypothèses de départ, nous avons pu démontrer qu'un certain nombre de variables influençait les deux processus différemment -- et donc, par ce fait-là, justifiait la dichotomie. D'abord nous avons démontré des modes de développement particuliers pour les deux processus; ensuite, en examinant de plus près le développement des sujets, nous avons pu démontrer que les garçons ressemblaient aux filles lorsqu'on parlait de processus non-linguistiques, mais différaient de celles-là -- conformément à nos attentes -- lorsqu'on faisait appel aux autres processus. En troisième lieu, nous avons pu démontrer -- encore en ligne avec une hypothèse dichotomique -- des effets sur le processus linguistique seulement par l'existence d'un second système linguistique chez certains sujets. Finalement et inopinément, une erreur de parcours n'eut d'effet -- comme l'auraient prévu nos hypothèses -- que sur le processus linguistique. Nous avons discuté de ces résultats surtout par rapport aux autres expériences dans la littérature qui ont trait au concept de "mode phonétique".

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CHAPTER 1

General Introduction

This thesis is concerned with the nature of speech perception, with particular reference to the distinction between linguistic and non-linguistic processes in speech perception. Before describing a series of studies that was carried out to gain further insight into the distinction between linguistic and non-linguistic processes, we will go into some of the research which has led scientists to postulate and debate about dichotomous processes.

CLASSIFICATION OF SPEECH SOUNDS

Speech sounds can be classified at three different levels: the featural, the phonetic, and the phonemic. At the first level, the featural level, we apparently perceive a sound such as 'p' in the word 'pot' as being composed of a number of *features*. For example, it contains the feature voiceless (as opposed to 'b' in 'bit' which contains the feature voiced). Also, it contains the feature labial (as opposed to 'dot', which contains the feature alveolar). And so forth. These features have been defined by linguists mainly articulatorily, and, by psychologists, mainly perceptually. Articulatorily, for example, the feature voiced corresponds to vibration of the vocal cords, whereas the feature voiceless does not. Also, the feature labial corresponds to closure at the lips whereas the feature alveolar corresponds to closure at the alveolar ridge (Ladefoged, 1975). Perceptually, the reality of features is confirmed for example, by the studies of Miller and Nicely on perceptual distances between speech sounds (Miller & Nicely, 1955). Second, we perceive it as a member of a given *phonetic* class, [pʰ], namely that of the aspirated bilabial voiceless etc, stop consonant (the square brackets is the traditional method used by linguists to refer to a phonetic segment (Hyman, 1975) and will be used throughout the thesis for this purpose). The existence of such a classification is postulated on the basis of studies of languages: more specifically, each language contains both an idiosyncratic and a limited (out of the range of possible) inventory of combinations of features to yield its distinctive set of phonetic segments (Ruhlen, 1976). Part of learning a new language often entails learning to perceive and produce new phonetic segments: one such evidence, for example, is the difficulty Québec francophones often exhibit when learning to pronounce the 'th' sound (which corresponds to the phonetic segment [ð] of the English word 'this', pronouncing it as the phonetic segment [d] (Picard, M. & J. Nicol, 1982). Finally, we perceive it as a member of a given *phonemic* class, namely /p/ (the two slashes flanking a speech sound is the traditional method used by linguists to refer to a phonemic segment (Hyman, 1975) and will be used throughout the thesis for this purpose). There are number of modes of defining a phoneme. To keep matters simple, we have decided to adopt the simplest approach, the strict phonemic approach, for the entirety of this thesis. Within this approach, the definition of the phoneme is the following: a) sounds which belong to the same phoneme share important phonetic properties. For example, the North American English phoneme /t/ consists, at the least, of the following phonetic forms [tʰ], [t], [t˺], [t̪], whereas the phoneme /d/ consists of the following phonetic forms [d], [d̪], (Nicole Domingue, personal communication; Marc Picard, 1987). (Characteristics such as aspiration -- that is, 'ʰ' --, unreleasedness -- that is '˺' --, dentalness as opposed to the usual alveolarness -- that is '̪', are relatively minor aspects of the phonetic segments); b) phonemes are capable of distinguishing words of different meanings: that is, two words which differ in the type of phonemes but not their arrangement by one phoneme only produce two words of different meaning (for example the two English words 'bad' versus 'bat' differ phonemically only by the phonemes /t/ versus /d/, and thus signify different things); c) phonetic forms of given phonemes may exist in so-called 'complementary distribution', (that is, for example, one phonetic form of a given phoneme may occur only in certain given contexts, while another phonetic form of the same phoneme may occur only in certain other contexts. Furthermore, the two phonetic forms cannot occur in the same environment as minimal pairs to yield two different meaningful units. If they are artificially placed one instead of the other in such a context, the resulting words may possibly sound 'foreign' or 'strange' versus 'native' or 'ordinary', but not meaningfully different (Hyman, 1975)). (An example of complementary distribution in the English language as spoken in North America (Nicole Domingue, personal communication; Marc Picard, 1987) would be that the phonetic form [tʰ] occurs only in word initial position, such as in [tʰ] [a] [p] of the word 'top', whereas the [t] form occurs medially as in [s] [t] [a] [p] of the word 'stop'). Finally, d) phonetic forms of given phonemes may exist in so-called 'free variation', that is, more than one phonetic form may occur in certain given contexts (for example, again in the English language, the unreleased [t˺] phonetic form occurs mostly at the end of words as in [h] [æ] [t˺] of the word 'hat', but [t] may also occur in that position as in [h] [æ] [t] also of the word 'hat'. The strict phonemic approach also seems implicitly to be the approach adopted by the literature this thesis deals with. That the phonemes as defined above by linguists, are also perceived by subjects is attested to by their capacity to track such phonemes in lists of words presented to them (Savin & Bever, 1970).

As defined above, the three modes of classifying speech sounds are hierarchically organized, the lowest level being the feature, next the segment, and the highest level being the phoneme: the upper levels are built upon, and subsume the lower levels. For the purposes of the present thesis, and for reasons that have to do with the questions addressed by this thesis, we shall, most of the time, not dwell upon any differences which may exist between the three modes of classification of speech sounds: the featural, the segmental, and the phonemic. Both the literature to be discussed which has dealt with the modes of processing speech sounds, as well as the experiments carried out for this thesis, have implicitly focused upon the common element in all three classifications, namely the first level of classification, the feature, and not their differences.

ONE THEORY OF SPEECH PERCEPTION

Most current theorists who have proposed models of speech perception have made a distinction between two levels of processing (for a brief review of these theories, see Pisoni, 1978). The first level is usually referred to as an auditory or acoustic level of processing, and the second level is mostly referred to as a phonetic level, although terms such as featural level, phonetic segmental level, and phonemic level are also employed to refer roughly to the same thing (as alluded to in the previous section). We shall also, at times, use the term linguistic to refer to this second level, and non-linguistic to refer to the first level.

The present thesis will focus upon the two levels of processing as these have been postulated to exist and operate by A.M. Liberman and his colleagues at the Haskins Laboratories over a number of years (Liberman, 1970; Liberman, 1981; Liberman, Cooper, Shankweiler & Studdert-Kennedy, 1967; Repp, 1981b; Studdert-Kennedy, 1976).

Working on physical procedures to synthesize speech, Liberman and his colleagues come to the conclusion that there exists a so-called phonetic mode, which is distinct from an auditory mode. Further, the phonetic mode has as its main characteristic the fact that it is closely allied to mechanisms responsible for the production of speech.

PHYSICAL CHARACTERISTICS OF SPEECH SOUNDS AND THE PHONETIC MODE

Liberman and his colleagues have used the spectrogram to synthesize and analyze speech sounds. Many arguments based on the physical characteristics of speech sounds are used by Liberman and his colleagues to argue for the existence of a speech mode (equivalent to a phonetic mode). One of these arguments is the lack of physical invariance in the speech signal despite the presence of a psychological invariance. As will be briefly shown below, it is difficult to see how some simple auditory mode of categorization could account for such tremendous variability in physical cues.

As can be seen in Figure 1 for given stop consonants in a given syllabic position but with different vowels (e.g. di, de, da, etc.), the shape as well as the location of, for example, the second formant transition, for 2-formant patterns, is extremely variable. The only 'invariant' that can be postulated to exist in such a case is the 'locus' from which the second formant transition arises. However, this locus would necessarily have to be an 'inferred' locus because synthetic stimuli created with the formant actually starting at the locus, create perceptually different categories of sounds. More specifically, as can be seen in Figure 2, second-formant transitions that start at the /d/ locus produce syllables beginning with /b/, /d/, or /g/, depending on the frequency-level of the formant. However, comparable transitions that merely point at the /d/ locus (as indicated by the dotted lines) produce only syllables beginning with /d/. However, even the notion of an 'inferred' invariant locus seems to have to be further modified, when examining given consonants varying in syllabic position: for whereas for a CV consonant, the inferred invariant locus is to be the one *from which* the second formant *arises*, for a VC consonant, the inferred invariant locus is to be the one *toward which* the second formant *terminates*. As can be seen in Figure 3, the cue for the stop consonant [d] at the beginning versus the end of [did] is the locus from which the second formant arises versus the locus toward which the second formant terminates.

Figure 1: **Schematized sound spectrograms showing the formant transitions that are appropriate for the voiced stop sonsonants [b], [d], [g] before various vowels (Delattre, Liberman & Cooper, 1955 (cited in Pisoni, 1978)) (Used by permission)**

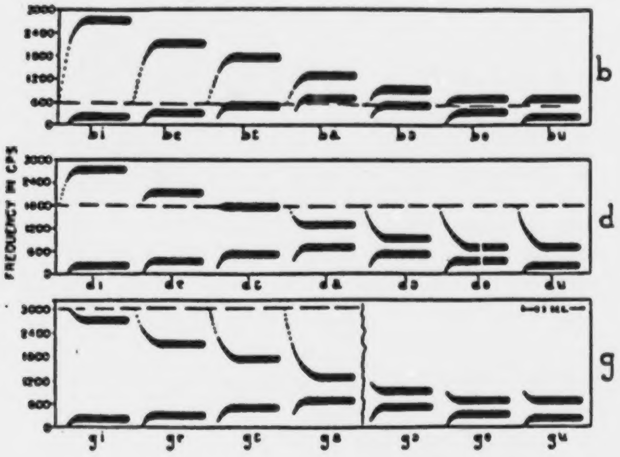


Figure 2: **A - Second-formant transitions that start at the /d/ locus.**
B - Comparable transitions that merely "point" at it, as indicated by the dotted lines.
(Delattre, Liberman & Cooper, 1955 (cited in Liberman, Cooper, Shankweiler & Studdert-Kennedy, 1967)) (Used by permission)

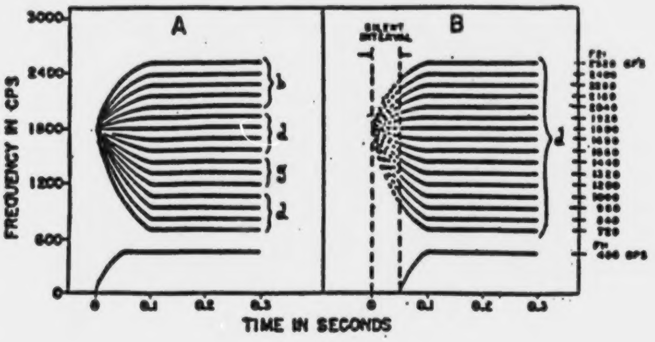
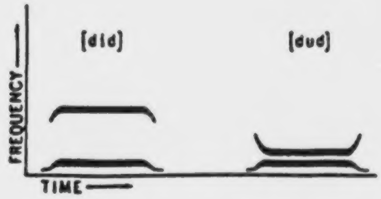


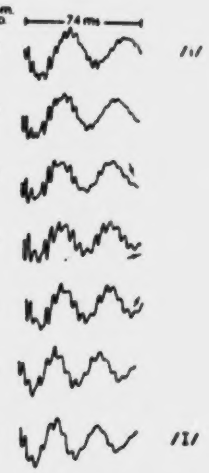
Figure 3: Spectrograms sufficient to produce the syllables [did] and [dud] (Liberman & Studdert-Kennedy, 1978) (Used by permission)



On the basis of the above findings, Liberman et al. (1967) go on to postulate that the commands to the articulators provide the explanation for the perceived invariance. We shall not go into how this fit is postulated to be achieved.

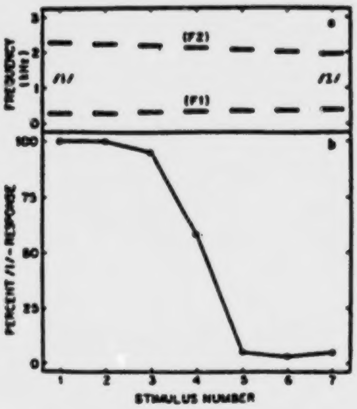
Some researchers have recently suggested that the mode of applying spectrographic analysis of speech sounds (Stevens & Blumstein, 1981), or the procedure itself (Scott, 1980), may not be psychologically valid. Scott (1980), claimed that the speech signal contains invariant acoustic cues. According to him, if we examine the oscilloscope trace rather than the spectrograph, there are clear invariant cues to speech sounds. For this, the signal must be perceived as integrated across frequency in time, and must be treated by the perceptual system as an integrated signal in which the important cues exist as relations between spectral components. A look at Figure 4 and Figure 5 will show how an oscilloscopic (Figure 4) view of /i/ versus /I/ will explain more easily how our percept changes from /i/ to /I/ compared to a spectrographic view (Figure 5) of these vowels. Researchers such as Stevens (1980) hypothesize both the existence of invariants in the signal as well as context-dependent cues. Nevertheless, the views of both Scott (1980) and Stevens (1980) are fairly recent and have not been as amply researched as those of Liberman and his colleagues.

Figure 4: Oscilloscopic representation of a synthesized seven-vowel series from /i/ to /I/ (Scott, 1980) (Used by permission)



NOTE
CHANGE
OF
ARROW
DIRECTION

Figure 5: **Panel a.** Spectrographic representation of the /i/, /I/ vowels of Figure 4 shows formant center frequency values for each of the seven stimuli.
Panel b. Perceptual boundary for Panel a series in terms of percent of /i/ responses
(Scott, 1980) (Used by permission)



PSYCHOLOGICAL STUDIES ON SPEECH SOUNDS AND THE PHONETIC MODE

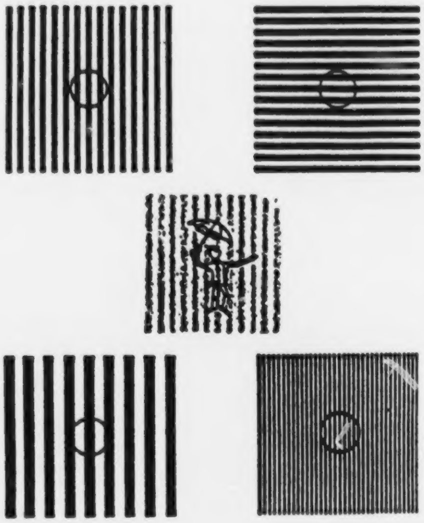
In the adult speech perception literature, there has been an attempt to distinguish between auditory and phonetic levels of processing. "In brief summary, the auditory level is assumed to perform an analysis of the acoustic speech signal resulting in a corresponding set of non-linguistic parameters such as the frequency spectrum of the signal, its amplitude, and changes in these parameters over time. In contrast, the phonetic level is assumed to perform abstract linguistic processes by which the particular acoustic cue or complex of cues for a given phonetic feature are extracted from the output of the auditory level" (Wood, 1975, p. 55). Other terms that have been used for these two processes are: acoustic processes on one hand, and rule governed or context-dependent processes, on the other.

One attempt to demonstrate the special nature of phonetic perception has involved selective adaptation of feature detectors for speech. We will describe the evidence initially adduced to use this phenomenon as an argument in favour of dichotomous auditory and linguistic (or phonetic) processes in speech perception, and will then describe the more recent evidence which casts doubt on the above conclusions.

Visual Feature Detectors

In the visual domain, after a human observer has been visually exposed to gratings of a certain size and orientation for some 30-60 seconds, similar but very dim gratings will not be discernible. Thus, after viewing the upper left grating of Figure 6 for the required time, exposure to the center image results in the absence of the very dim gratings for about 30-60 seconds. This does not occur when the subject views either of the other three gratings before being exposed to the center image. That is, the phenomenon will not be observed if adaptation (that is the 30-60 second pre-exposure) has been with gratings of another dimension or orientation than that in the test one. The explanation for this phenomenon has been that there are "orientation detectors" that are stimulated by specific sizes and orientations, that they fatigue after a certain period of time so that weak stimuli are not registered. The evidence for such visual detectors is both perceptual and electrophysiological. Evoked potential studies have found evidence concordant with the perceptual observations cited above (Goldstein, 1980).

Figure 6: Stimuli used to demonstrate adaptation in visual domain (Blakemore & Campbell, 1968 (cited in Goldstein, 1980))



Feature Detectors for Speech

In the speech domain, Eimas and Corbit (1973) discovered a phenomenon which resembled that described above for vision. They subsequently postulated the existence of detectors in the area of speech.

In vision, the stimuli are lines of particular shape, size, orientation, and color. Correspondingly, the detectors assumed to respond to these stimuli are detectors for a given shape, size, orientation and color. Furthermore, the detectors have certain given characteristics, one of which is reduced responding after a certain amount of stimulation.

In speech, the stimuli are "linguistic features" and the postulated detectors assumed to respond to these stimuli are detectors for "linguistic features". The postulated detectors have some characteristics which are similar and others which are different from those of vision. One similar characteristic is reduced responding after a certain amount of stimulation.

Unlike the lines of particular size or orientation in vision, the linguistic features for which detectors are postulated are inferred, rather than directly observable or reproducible entities. To measure their operation, the following technique is employed: "let's consider the characteristics of two stimuli, /ba/ and /pa/. The initial consonants of these sounds differ in only one distinctive feature, voicing, with /b/ being voiced and /p/ being unvoiced. This difference between /b/ and /p/ causes the [productive] characteristic called *voice onset time* (VOT), ... , to differ for /ba/ and /pa/.

The difference in VOT for /ba/ and /pa/ is illustrated by the first two records in the spectrogram of Figure [7]. We can see from these spectrograms that the time between the beginning of the sound /ba/ and the beginning of voicing (indicated by the presence of vertical striations [i.e. very dark area] in the spectrogram) is 8 msec for /ba/ and 83 msec for /pa/. Thus, the voiced /b/ causes /ba/ to have a short VOT, and the unvoiced /p/ causes /pa/ to have a long VOT. A similar situation exists for the pairs /da/ and /ta/ shown in the other two spectrograms in Figure [7]. The voiced /d/ results in a VOT of 17 msec for /da/, whereas the unvoiced /t/ results in a VOT of 91 msec for /ta/.

... [generally] a computer is used to synthesize sounds corresponding to two consonant-vowel pairs such as /da/ and /ta/. The computer varies the VOT in small steps between about 0 and 80 msec, and the listener's task is to indicate whether a /da/ or a /ta/ is heard. The results of such an experiment are shown by the solid line in Figure [8] (Eimas & Corbit, 1973). When the VOT is 0 msec, 100 percent of the stimuli are identified as /da/, and increasing VOT has no effect until the VOT reaches about 30 msec. At this point, which is called the [phonetic boundary], listeners suddenly begin hearing /ta/, and when the VOT is increased just a little more to 40 msec, most of the stimuli are identified as /ta/." (Goldstein, 1980, pp. 394-395).

Figure 7: Spectrograms for /ba/, /pa/, /da/, and /ta/ (Cole (cited in Goldstein, 1980))

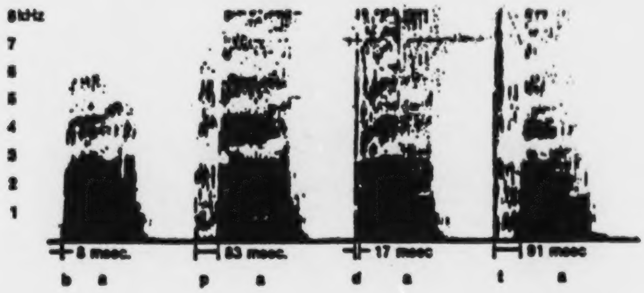
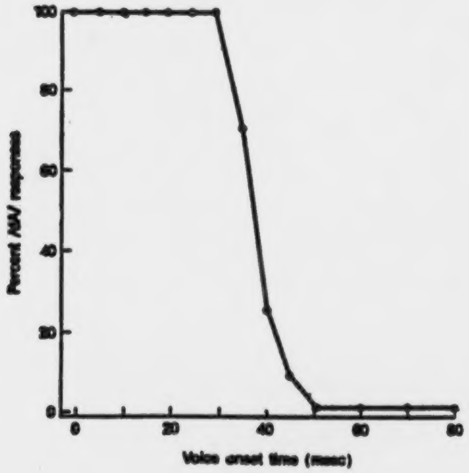


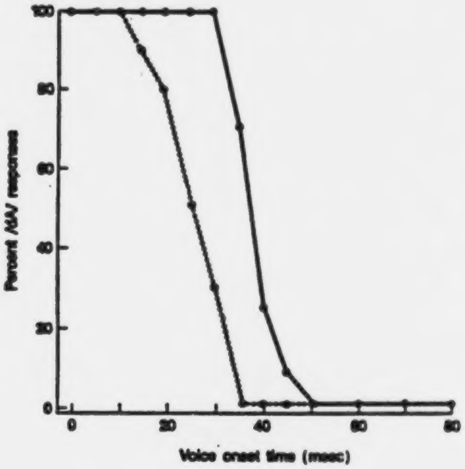
Figure 8: Percent of sounds identified as /da/ as voice onset time is varied from 0 to 80 msec (Eimas & Corbit, 1973 (cited in Goldstein, 1980)) (Used by permission)



Findings with Selective Adaptation of "Linguistic" Features

Eimas et al. (1973) "adapted" subjects by repeating a voiced syllable such as /da/ for two minutes, then having the subjects identify various synthetic tokens on the da - ta continuum. The results, as seen in Figure 9, were that the listener now perceived /ta/ at shorter VOT's than in the 'unadapted' state. Next, following adaptation to a voiced syllable such as /da/ for two minutes, they had subjects identify various synthetic tokens from a voiced/voiceless continuum *other* than da/ta, and found similar shifts in the perceived locus of the phonetic boundary. Because an adapting stimulus with a given property (e.g. the feature voiced) decreases the response to stimuli with such a property, Eimas et al. (1973) postulated the existence of feature detectors for speech. Furthermore, because such adaptation effects occurred *across* various speech sounds in which, as mentioned before, the acoustic property of the feature voiced is not clearly definable, they postulated that, unlike the visual detectors described above, these detectors responded to the feature VOT, a productive characteristic, and thus were "linguistic" detectors.

Figure 9: **Solid line:** **percent of sounds identified as /da/ as voice onset time is varied from 0 to 80 msec.**
Dotted line: **percent of sounds identified as /da/ as voice onset time is varied from 0 to 80 msec after adaptation to /da/ for two minutes.**
(Eimas & Corbit, 1973 (cited in Goldstein, 1980)) (Used by permission).



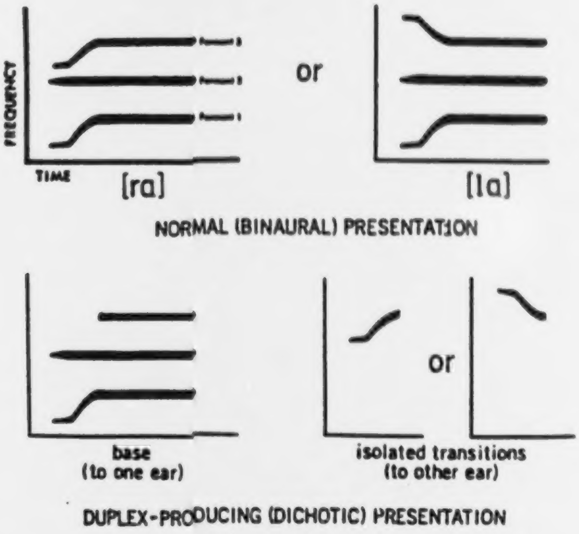
It should be noted that because these 'detectors' merely *shifted* the locus of the phonetic boundary rather than reducing all responsiveness to the feature which had been subject to the 'adaptation', the postulated properties for these are more elaborate than those for vision described above. These effects were subsequently used as confirmatory evidence for arguments about the nature of speech processing, that in addition to auditory processes, there must be specialized structures for dealing with speech.

There are several types of evidence now which seem to indicate that the adaptation effects cannot be completely (if at all) explained by the phonetic or linguistic characteristics of the adapting and test stimuli (Ades, 1974; Cooper, 1974; Howell, 1980; Sawusch & Pisoni, 1978). We shall describe only one. Cooper (1974) "adapted listeners with an alternating sequence of [da] and [ti]. The effects of adaptation were measured by comparing the locus of the phonetic boundary of a [ba - pa] series with the locus of a [bi - pi] series, both before and after adaptation. If voicing information is extracted independently of the vowel environment, then no adaptation effects should occur, inasmuch as the effects of simultaneously fatiguing the voiced and voiceless detectors should cancel each other. If, however, the analysis of voicing information is dependent on the vowel environment, then both series should show alterations in the locus of the phonetic boundary, but in opposite directions: the boundary for the [ba - pa] series should shift toward the voiced end of the continuum whereas the boundary for the [bi - pi] series should shift toward the voiceless end. The data were clearly in accord with a vowel-dependent analysis of voicing information." (Eimas & Miller, 1978, p. 314).

More recent attempts to demonstrate a dichotomy between auditory and linguistic modes of processing

Other phenomena, with similar postulates have been proposed. They are the phenomena of the "trading relations" between the diverse acoustic cues of given speech sounds (Liberman, 1981; Repp, 1981a), and the phenomenon of "duplex perception" (Liberman, Isenberg & Rakerd, 1981). We shall describe only the latter. "First, the syllables [ra] and [la], shown schematically in the top half of Figure [10], were synthesized so as to make the perceived distinction depend entirely on the transition of the third formant. Then, as shown in the bottom half of the figure, these patterns were divided into two constituents. One constituent, labeled "base" and shown at the left, included all aspects of the pattern that were identical in the two syllables. When presented by itself, this common core was perceived as a syllable, almost always as [ra]. The other constituent, shown to the right, was one or the other of the third-formant transitions that, in the undivided syllable, critically distinguished [ra] from [la]. In isolation, these transitions were perceived variously, but in no case did they sound the same as when, in the undivided patterns, they were essential to the difference between the syllables; by most listeners, indeed, they were thought to be not-very-speechlike, but discriminably different, "chirps". The last, and critical, step was to put the base into one ear and one or the other of the isolated transitions into the other, being careful, of course, to make the temporal relation between the dichotically presented constituents the same as it had been in the undivided patterns.

Figure 10: **Schematic representations of patterns appropriate for duplex perception of [ra] and [la] (Liberman, Isenberg & Rakerd, 1981) (Used by permission)**



The result was a duplex percept. One component was a syllable that listeners "correctly" perceived as [ra] or [la] according to the nature of the third-formant transition. The other component, perceived at the same time as the syllable, was a not-very-speechlike chirp. This percept corresponded to the one that had been produced by the third-formant transition in isolation.

... Quite remarkably, it was duplex, which is to say that it represented two ways of processing the stimuli: as speech and as non-speech." (Liberman, Isenberg & Rakerd, 1981, pp. 133-135).

This phenomenon, taken as evidence of auditory and linguistic processing of speech sounds, is too recent to have been the subject of further tests and explanations.

RATIONALE FOR THE PRESENT RESEARCH

Although what characterizes the "phonetic mode" is somewhat vague (mainly by exclusion and as it correlates with the productive aspects of language), what is also unclear, both from the theory and from the data amassed by the Haskins researchers, is to what extent speech is processed by the "auditory mode".

By a series of studies which aims to extend and further refine previous work in this area, we will try to shed more light on the existence of the two dichotomous processes. We shall define phonetic mode in the same manner as Liberman and his colleagues: that is, something specifically linguistic, and preferably related to productive aspects of language.

In this thesis, then, a series of studies was carried out to obtain more insight into the possible distinction between auditory and phonetic processes in speech perception. The general strategy for exploring the distinction was to attempt to devise tasks which required auditory and/or phonetic processing, and to determine how task performance varied with age, sex and later on degree of second-language abilities of subjects. The following questions were asked: 1. Are two separate modes of processing involved in speech perception? 2. If so, is one 'auditory', and the other one 'phonetic'?

CHAPTER 2

Study 1: Auditory Versus Phonetic Processes in the Discrimination of Consonants

INTRODUCTION

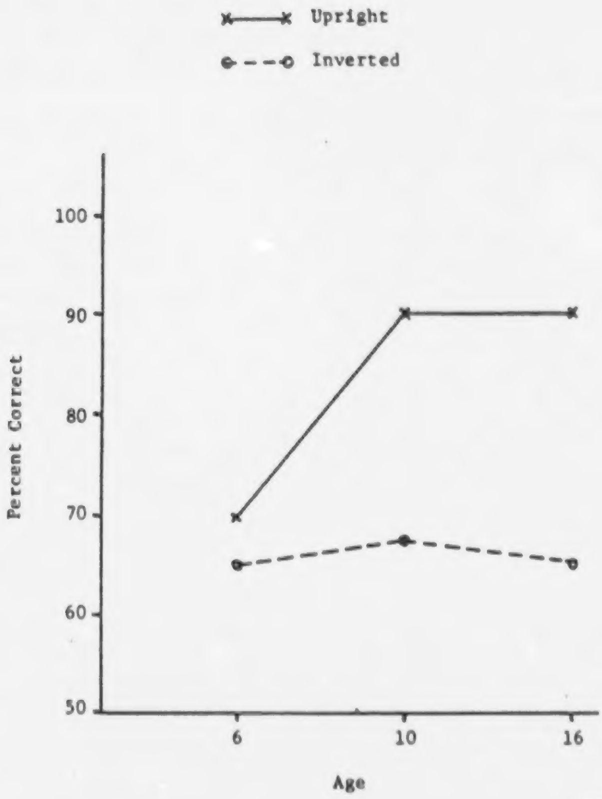
This study represented the first attempt to answer the question whether there exists two separate processes in the perception of speech. One general strategy throughout the thesis will be to look for different patterns of development in the particular ages chosen for tasks set out to tap two different modes of processing speech sounds. Our justification for linking different patterns of development to possibly two different modes of processing speech sounds is the following. In the general area of development, we may distinguish grossly between experiments with what we shall call "simple" stimuli versus "complex" stimuli. Simple stimuli would be stimuli with easy to define physical attributes (e.g. color, for example). Complex stimuli, on the other hand, do not, for a complete description, possess such easy to define dimensions (e.g. faces, for example). The pattern of development presumed to underlie categorization of simple versus complex stimuli is theoretically different. Color categories are presumed to be formed very early (Bornstein, Kessen & Weiskoff, 1976 claim by 4 months, but see Mervis, Catlin & Rosch, 1975) and are presumed to depend by and large on the pattern of activation of spectrally opponent cell types (de Valois & de Valois, 1975).

On the other hand, categorization of complex stimuli, such as faces, for example, do not seem to reach adult levels until age ten or more (Carey-Block, 1978; Carey, Diamond & Woods, 1980) and their processing is presumed to undergo different stages throughout development. Specifically, many developmental theorists argue that perception of such complex stimuli proceeds (with variations) from an idiosyncratic or global perception of the object to perception of simple dimensions of the object and eventually to perception of the complex dimensions themselves (Fischer, 1980; Gibson, 1969; Tighe & Tighe, 1978; Vygotsky, 1962).

Since speech has been described by Liberman and his colleagues as a "complex" stimulus, we may hypothesize that development of its processing should parallel in some way the development of other complex stimuli. Furthermore, we shall make the assumption that the simple dimensions of complex stimuli resemble auditory processing of speech stimuli, whereas the complex dimensions of complex stimuli resemble the phonetic processing of speech sounds.

In attempting to answer the question as to whether there exist two separate processes in the perception of speech, we borrowed from a useful paradigm in the area of the development of face perception. The paradigm was the following: Subjects are asked to recognize faces previously presented for familiarization, faces presented either in the UPRIGHT or in the INVERTED position. Individuals' faces are presented, each in the upright and in the inverted position. As can be seen in Figure 11, recognition of such faces at ages six, ten, and sixteen is the following: inverted faces are recognized at approximately 65% correct at all three age levels; upright faces are recognized at approximately 70% correct at age six, and at 90% correct at ages ten and sixteen (Carey-Block, 1978). Because there is no significant difference at age six in the performance on the Upright versus Inverted faces, but there is one from age ten onwards, and aided by other corroborating evidence, it has been postulated that at age six encoding of upward faces is piecemeal, and starting at age ten, it becomes configurational (Carey-Block, 1978; Carey et al., 1980).

Figure 11: Recognition of faces as a function of age (Carey-Block, 1978: Ages 6, 10, 16 only)



In the present study native and foreign speech contrasts were used instead of upright and inverted faces. Whereas Carey-Block (1978) and Carey et al. (1980) utilized a recognition memory paradigm and a matching paradigm, we used the two-interval same-different paradigm. Just as in the face example, the stimuli were chosen in such a way as to be classifiable on the basis of "piecemeal" properties, and also on the basis of "configurational" properties. Therefore, if these exhibited the same developmental pattern as for face perception above, it could be assumed that at least two different processes were at work in speech perception.

As has already been alluded to earlier, the distinctions between "phonetic" and "auditory" processes as made by Liberman and his colleagues are rather difficult to define. In large measure, "auditory" processes seem to exhibit commonalities with other findings in the field of auditory perception of simple acoustic stimuli, whereas "phonetic" processes do not. "Phonetic" processes seem to be largely confined to complex speech stimuli, and seem to be more readily explained by mechanisms responsible for the production of speech.

One hypothesis we have entertained within this study is that "configurational" processing of speech sounds should be more akin to "phonetic" processes as defined by Liberman and his colleagues, whereas "piecemeal" processing of speech sounds should be more akin to "auditory" processes. The reason for the following line of thought is that in the former type of processing, more abstract, or highly 'encoded' forms of the stimuli seem to be involved, not easily definable in terms of frequency, amplitude or time, whereas in the latter type of processing, simple, or not 'encoded' aspects of the stimuli seem to be involved, here easily definable in terms of frequency, amplitude or time. We therefore expect the trends postulated for "configurational" versus "piecemeal" modes of processing to also somewhat confirm "phonetic" versus "auditory" modes of processing. We have added another variable as an index of auditory versus phonetic processing, namely Sex.

In particular, we expect the shift from auditory to phonetic processing to lag behind for males with respect to females. There are two reasons which prompt such a conclusion. The first has to do with developing males' performance in the area of language in general. In effect, although data in the area of speech perception are mostly lacking, that in all other areas of linguistic functioning point to a differently maturing linguistic system for males compared to females.

In the area of speech perception (whether we are dealing, for example, with categorization studies (Graham and House, 1970; Miller and Nicely, 1955), or categorical perception studies (Eimas, 1978; Liberman et al., 1967; Wolf, 1973), it seems to be the rule that sex is either not controlled for, or not analyzed, as a variable. The general result of this is that data with respect to sex differences in speech perception are lacking. Nevertheless, in the general area of linguistic functioning, the vast amounts of literature have been summarized by Maccoby and Jacklin, 1978 (and appear to be still valid today (Halpern, 1986)). Their general conclusions (on variables ranging from spelling and punctuation, through comprehension of complex written text, to understanding of complex logical relations and verbal creativity) are that till ages 2 - 3, females seem to have a clear advantage over males - although the relevant studies may be problematic -, and, in the pre-school and early school years no consistent differences are found (although where there do exist differences, they favor females). Finally, a clear female superiority appears to start at age 10-11 and then persist throughout the high school and college years (Maccoby and Jacklin, 1978).

On the basis of these data -- especially the advantage to age 3, then the equality in the early school years -- we will postulate that the shift from auditory to phonetic processing should lag behind for males. Although the ages postulated for retardation and catching up do not conform strictly to those appearing in the Maccoby and Jacklin (1978) results, (we are postulating that at age 6 males will be behind females and will have caught up around age 10), since the age range we will be investigating covers early childhood to adulthood, other patterns of delay versus equality for the phonetic process would still confirm our hypothesis of the existence of two separate processes, one linguistic (i.e. that showing a developmental delay), one non-linguistic (that showing no delay).

The second reason motivating our general hypothesis has to do with pathologies exhibited by developing males in areas postulated to have close links to the domain of language. In particular, we will look into the sex pattern of a well-known disorder of reading called dyslexia. We will then briefly justify the hypothesized relationship between reading and language in general as well as speech perception in particular.

In a well designed study by Symmes and Rapoport (1972), the sex profile of reading disabled children aged 7 to 13 was examined. In fact of 108 "learning-disabled" children thus collected, 39 males and 15 females were finally rejected preponderantly because of the possibility of the reading disability being secondary to some other disorder. Thus 54 "pure" cases were left, *all* male (i.e. 100% males). Corballis and Beale (1983, p. 235) also report, as have other researchers as well, that dyslexia is a preponderantly male disorder.

Vellutino (1979) in a book devoted to the research on dyslexia, finds clear relationships between reading disability and difficulties with language functions in general. In the specific area of speech, he notes that although there is no evidence that poor readers do badly on tests of auditory discrimination, there is a lot of evidence that poor reading is correlated with difficulty in "phonetic coding" as well as with difficulties in phonemic segmentation.

Finally, Symmes and Rapoport (1972), on the basis of their "male only" dyslexic population, put forth the hypothesis that dyslexia may have a sex-linked genetic basis.

And so, this overwhelming presence of males in dyslexia may further point to a general predisposition in young males *in general* to be somewhat poorer (compared to females) in the performance of linguistic tasks.

Thus, on the basis of these data, we would postulate the shift from auditory to phonetic processing to be at the very least less substantial for males compared to females (although a lag in the shift for males would not contradict young males' presumed weaker system).

Finally, we expect that knowledge of a secondary linguistic system should differentially influence phonetic versus auditory modes of processing, for reasons that will be elaborated upon further on in the thesis. For this reason, to simplify for the moment any possible effects of this variable on the questions of interest, we have carefully screened our subjects to yield only unilinguals.

METHOD

In this study pairs of native and foreign phonemic contrasts sharing a common physical characteristic were presented auditorily to unilingual males and females aged 4 - 6, 6 - 8, 10 - 12, and 16 - 18 for same-different judgments. It was hypothesized that at ages 6 - 8 and below there would be no difference in performance between Native and Foreign contrasts but that at ages 10 - 12 and above, there would be a significant difference resulting from an improvement in the discrimination of native contrasts. The latter change in developmental pattern was hypothesized to occur somewhat later in males than in females.

Subjects

All subjects were unilingual francophones. As knowledge of other language systems could theoretically influence native language categories, this precaution in selection was judged to be necessary. They all came from mainly upper and upper-middle class areas of Montreal. All had a normal auditory history. They came from both public and private schools. They belonged to four age groups: ages 4 - 6, 6 - 8, 10 - 12, 16 - 18.

Subjects were selected for unilingualism in the following way:

1. The 4 - 6 year olds and 6 - 8 year olds had to speak and comprehend only French according to the teacher's report, the child's report, and the language spoken in the home by both parents (French only) as well as answers to testing by the experimenter (for questions asked and criteria for inclusion in the study see Appendix 1).

2. The 10 - 12 year olds had to speak and comprehend only French according to an extensive questionnaire of the subject's background, knowledge and use of his language or languages. The questionnaire was a French age-adjusted adaptation of the one used by Vaid and Lambert (1979) (for questionnaire and criteria for inclusion in the study see Appendix 1).

3. The 16 - 18 year olds had to speak and comprehend only French according to the French-adapted Vaid and Lambert (1979) questionnaire and to performance on a test of English comprehension (Harris & Palmer) (for questionnaire and English Comprehension test and criteria for inclusion in the study see Appendix 1).

The criteria for normal auditory history were:

1. At ages 4 - 6 and 6 - 8, no hearing problems were mentioned in the school medical report, where available, or in the teacher's report.

2. At ages 10 - 12 and 16 - 18, there was a negative response to the following question:

   As-tu jamais eu des problèmes avec tes oreilles ou ton audition? (Entends-tu mal? As-tu eu des tubes dans les oreilles? As-tu eu une opération aux oreilles?)

   Si oui, coches ici ______
   Si non, coches ici ______

The number of subjects by age and sex were: 12 male and 12 female children ages 4 - 6 (female mean = five years, six months, male mean = five years, seven months); 12 male and 12 female children ages 6 - 8 (female mean = six years, eight months, male mean = six years, 11 months); 12 male and 12 female children ages 10 - 12 (female mean = ten years, nine months, male mean = 11 years, one month); 12 male and 12 female adults ages 16 - 18 (female mean = 17 years, 0 months, male mean = 16 years, eight months).

Subjects came from the following schools in Montreal:

1. At ages 4 - 6, 6 - 8, they came from three schools in the Notre-Dame-de-Grâce area, École Notre-Dame-de-Grâce (public school), École Saint-Antonin (public school), and Cours Chateaubriand (private school).

2. At ages 10 - 12, they came from a school in the Outremont area, Collège Stanislas (private school).

3. At ages 16 - 18, they came from the following schools: the males from Collège Stanislas (private school), and the females from Pensionnat du St-Nom-de-Jésus-Marie (private school), two schools in the Outremont area.

Stimuli

The stimuli were selected to represent four featural contrasts (Ladefoged, 1975), three native, one foreign. The three native contrasts were voicing (e.g. p/b), place of articulation (e.g. p/k), degree of obstruction (e.g. p/f), all phonemic in French and English. The fourth contrast, duration, is phonemic only in other languages, such as Hungarian. Hungarian contains all the consonants existing in English plus an identical set to which has been added one feature, that they are longer (e.g. p/p̄, b/b̄, k/k̄, etc., with the bar over the consonant indicating that it is longer). The contrasts of main interest were the Voicing and the Duration (Foreign) contrasts. In both cases, one of the important cues is duration, represented as short versus long acoustic features (for voicing: Ling, 1976; for Hungarian: Benkő & Imre, 1972). As can be seen in Figure 12, one characteristic differentiating the native aba from apa is the duration of silence preceding voicing: short for aba, long for apa. Similarly, in Figure 13, one characteristic differentiating the foreign aba from ab̄a is also the duration of silence preceding voicing: short for aba, long for ab̄a. The other two contrasts, place and obstruction, were added for general comparison purposes.

The speakers were one male and one female native Hungarians. Each speaker was recorded individually in a quiet room. The recording equipment used was a SONY stereo reel to reel Tape recorder, TC-200 Serial No. 209220, a Philips EV7011/22 microphone, and polyester low noise 1.5 mil. tape. Recording was done at 7½ inches per second. A list of 16 Hungarian words, chosen to represent each of the actual stimuli embedded within actual words, was first used to get the speaker to practice speaking in Hungarian (e.g. *ava*l, b*aba*) (see Appendix 2 for list). Speakers were told they would have to utter invented Hungarian words. They were asked to pronounce them "as naturally as possible", leaving some space between each of these "words". The words were a list of 80 VCV utterances: the V's were always /a/, the C's were always one of 16 phonemes. The C phonemes were p, b, f, v, ʃ, ʒ, k, g, p̄, b̄, f̄, v̄, ʃ̄, ʒ̄, k̄, ḡ. Sample words were apa, aba, afa, etc., ap̄a, ab̄a, etc. Each VCV was represented five times, and the overall order of phonemes was completely random (see Appendix 2).

Figure 12: Spectrograms of the native contrast aba-apa

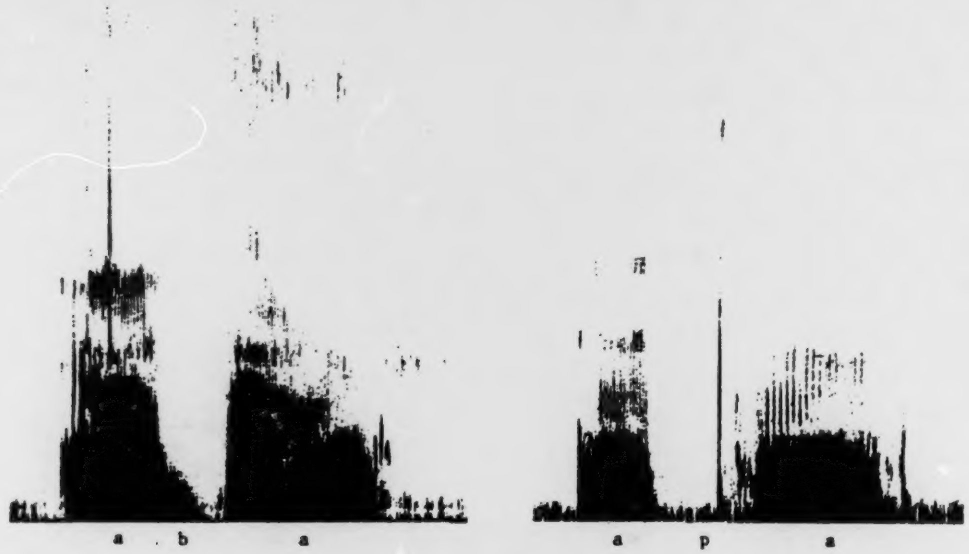
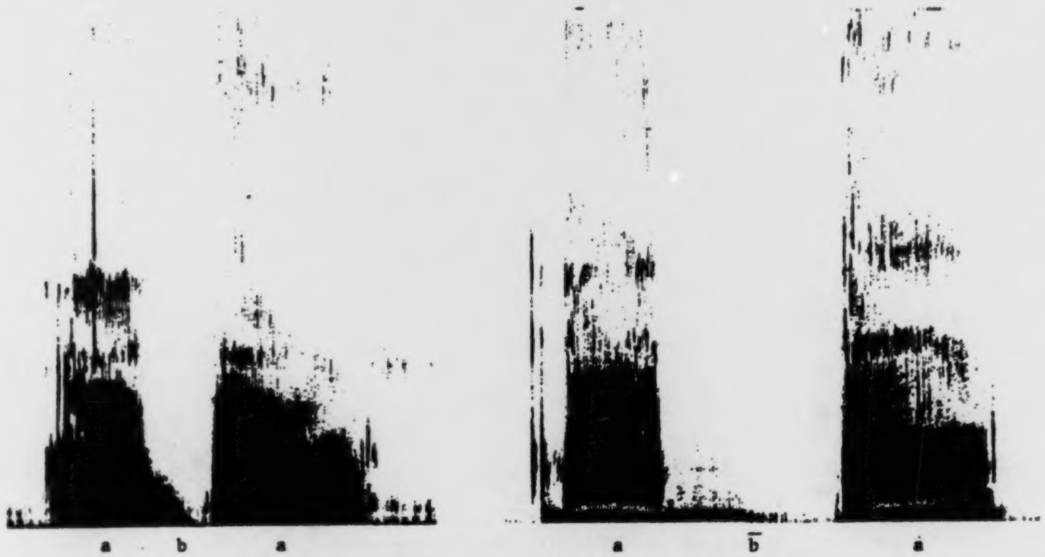


Figure 13: Spectrograms of the foreign contrast aba-ab̄a



Choice of best tokens

Three male and three female native Hungarians were used to judge the adequacy of the actual stimuli. They listened to the stimuli and had to write down what they heard as well as rate on a scale from one to five how certain they were about what they heard (see Appendix 2 for rating sheet). For the 80 stimuli heard, the mean errors were 2.3 for the male speaker and 6.8 for the female speaker. The words finally selected for the preparation of the Study tapes were those for which there were no errors of identification, and the degree of certainty was the highest.

Preparation of tapes

The aim was to present each subject with eight tokens of each of the four contrasts (voicing, place of articulation, degree of obstruction, and duration), plus a similar number of same pairs. This resulted in 64 pairs, 32 different, 32 same. The 64 pairs are shown in Appendix 2.

The words were spliced together with one second occurring between the words belonging to a pair and five seconds between pairs. Reproduction of stimuli from the master tape was done by a technician using a SONY taperecorder for playback (Model TC355, serial number 70162), an Ampex recorder-reproducer (Model AG600, serial number 428137) for duplicating, and an Ampex amplifier-loudspeaker (Model AA-620, serial number 0881-842) attached to the reproducer. Splicing was accomplished by marking off the beginning and end of each word using the Ampex recorder-reproducer (model AG-600, serial number 428137) and an Ampex amplifier-loudspeaker (Model AA-620, serial number 0881-842), attached to the reproducer. Splicing was accomplished by marking off the beginning and end of each word using the Ampex recorder-reproducer (Model AG-600, serial number 428137) and an Ampex amplifier-loudspeaker (Model AA-620, serial number 0881-842), and adding at each end the equivalent of .5 seconds in length (three and three-quarters inches). All pair-wise combinations were then spliced together. Pairs were then linked to one another by means of 4 second long (28 inches) empty tapes.

The order of pairs was randomized with the restriction that there were no more than three consecutive same or different pairs, and that the same speech sound did not appear in more than two consecutive pairs. Eight tapes were prepared, four with the female speaker, and four with the male speaker. For each speaker, the order of stimulus pairs was reversed on two of the tapes, and for each pair of tapes, the order of trials was reversed on one (Appendix 2 shows one of the resulting tapes).

Procedure

The experiment was conducted in a quiet room within a school. The testing was conducted by one of two assistants, a male Portuguese fluent in French or a male French Canadian. They had been told that they were to test how children discriminated between some sounds.

The subject sat at a table facing the assistant. The tape recorder (a SONY Stereo TC-200, Serial No. 209220) was to the left of the assistant, who could manipulate it easily.

The 4 to 6 year old subjects were first trained to respond 'yes' to similar pairs uttered by the experimenter and 'no' to dissimilar pairs by being first presented with real words (e.g. bateau-oiseau) and then invented words (e.g. bif-pak), with the invented words becoming progressively more difficult to discriminate (e.g. bik-mik). They were then told (in French) that the session would consist of hearing a pair of invented words, and that their task would be to say 'yes' if the pair was similar and 'no' if the pair was dissimilar. In addition, to motivate them to complete the 64 pairs, they were told that they would get one poker chip after every two answers. A stack of 24 poker chips was put in front of the child as an example of what the child before him (or her) had been able to achieve, obviously less than the 32 possible ones and thus easy to surpass. When it was clear that the child had understood perfectly the instructions, the experiment began. After every eight answers, the assistant reinforced the child by nodding approvingly or saying 'very well', 'you're doing very well'.

The older children and young adults were similarly trained but the response was a written one: 'O' for same, 'X' for different. No chips were used, but reinforcement was provided after every eight answers in the same manner as above. The exact procedures for each age group are given in Appendix 3, as they were delivered in French.

Subjects were eliminated if they did not wait for the pair to appear before giving their answer, or if they waited longer than five seconds before giving an answer.

Both the assistant and the child heard the stimuli through earphones -- the child's were Tokumi TE-1035 8ohm, the assistant's were KOSS Pro/4AA. The tape was played at a comfortable listening level, as determined by the assistant. The experimenter was present through most of the procedures, but was either hidden behind a screen or was sitting with her back turned to the child/assistant pair.

DESIGN

There were four age groups (4 - 6, 6 - 8, 10 - 12, 16 - 18) and two sexes (male, female), with 12 subjects nested within each of these age-sex cells. The subjects' response was 'same' or 'not the same'. The dependent variable was the d' score computed for each contrast level on the basis of the mean hit score for 'same' and mean false alarm score for 'different' tokens of the contrast in question. The reasons for using d' are given in the Discussion. The complete design is shown in Appendix 4.

The data were first analyzed by a three way ANOVA with repeated measures on one factor. This consisted of four levels of age (G) (4 - 6, 6 - 8, 10 - 12, 16 - 18), two levels of sex (X), and 12 subjects nested within each age-sex combination. The repeated factor was contrast (C), which consisted of four levels, three native (Voicing, Place, Obstruction) and one foreign (Duration). Although each subject heard seven tokens of voicing, eight tokens of place, nine tokens of obstruction (the seven versus nine due to error in formation of the tapes) and eight tokens of duration, only three tokens of voicing, four tokens of place, five tokens of obstruction and eight tokens of duration were actually used in the analyses, because of an error in the original rationale for choosing the given tokens. The factors not analyzed were the sex of the speaker (male or female) (counterbalanced), the order of members of each pair (counterbalanced), and the order of the 64 pairs (quasi-randomized). Correlation coefficients were then calculated between the Contrasts Voicing and Duration at ages 6 - 8 and 10 - 12 followed by tests of significance of the correlation.

RESULTS

A complete tabular description of results done on the basis of the Analysis of Variance of the data can be found in Appendix 5. There were significant main effects for Age (F = 30.32, p. < .01) and Contrast (F = 84.74, p < .01) and a significant sex by Contrast interaction (F = 4.067, p. < .01). All other main effects and interactions were not significant. Therefore, the effect of age was not affected by other factors, but the effect of contrast interacted with sex. Comparisons between levels of age revealed the increase in age to be significant only between the G2 level (6 - 8) and the G3 level (10 -12) (see Appendix 5 and Figures 14 and 15. Figures 14 and 15 represent a plot of the d' scores for each type of contrast used at the four age levels employed. Figure 14 is the plot for females, Figure 15 is the plot for males).

The absence of the significant Age by Contrast interaction indicated that there was no differential difference between Native (Voicing) and Foreign (Duration) contrasts between the ages of interest, that is, ages 6 - 8 and 10 - 12. To detect the weaker expected relative developmental trends shown in Figure 11, in view of the fact the strongest test of Age by Contrast interaction was absent, *a priori*, the trend components of the Age effects were then analyzed for voicing and duration at each level of sex. Although the linear trend was significant throughout (F = 23.78, p < .01 (female, voicing), F = 27.46, p < .01 (male, voicing), F = 11.10, p < .01 (female, duration), F = 50.04, p < .01 (male, duration), the quadratic trend was significant only for the voicing contrast (F = 5.86, p < .01 (female, voicing), F = 4.02, p < .01 (male, voicing), F = .537, n.s. (female, duration), F = 3.42, n.s. (male, duration).

Figure 14: Study 1 - d' scores for discrimination of native or foreign contrasts for females by Age.

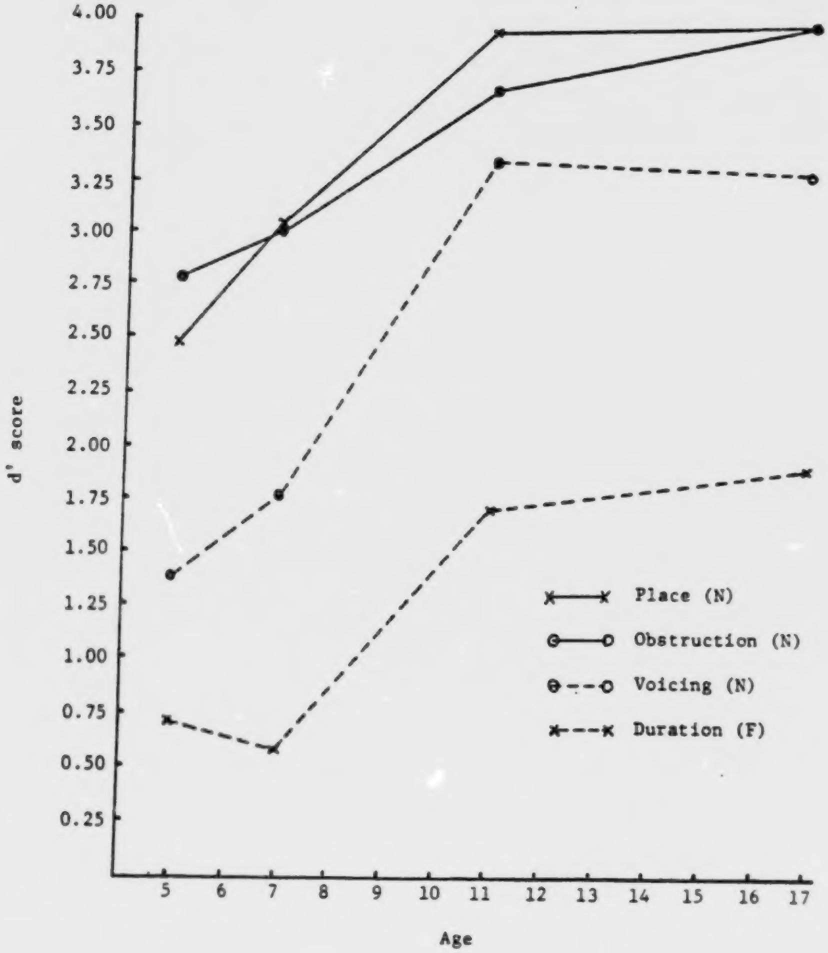
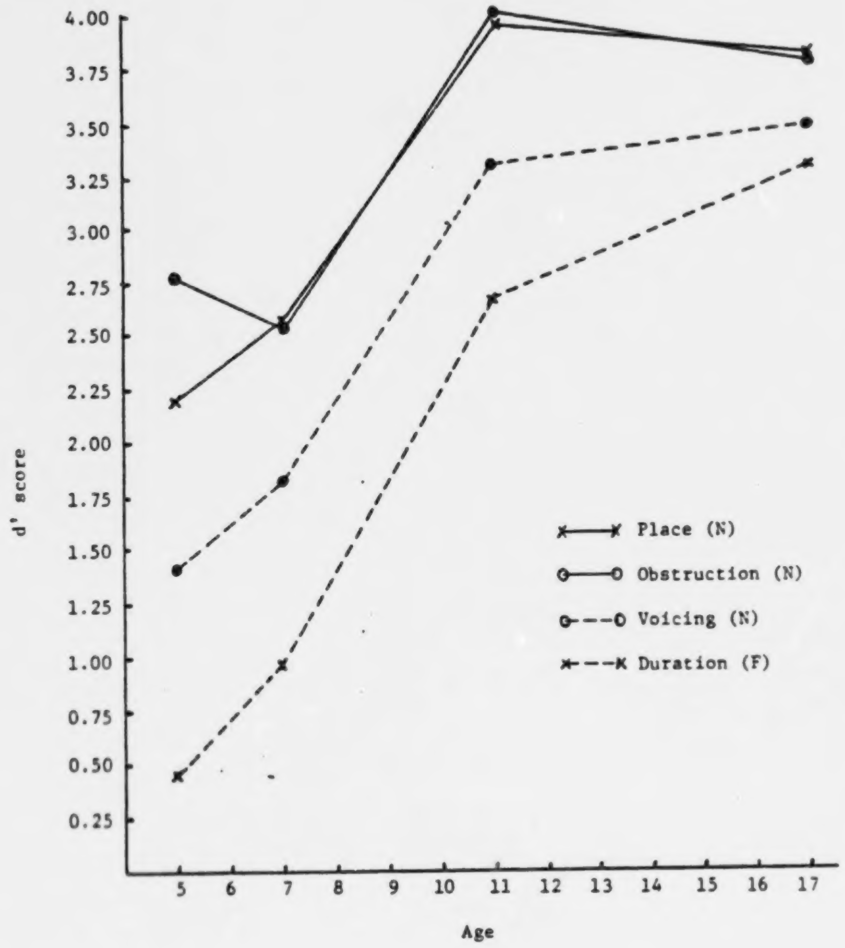
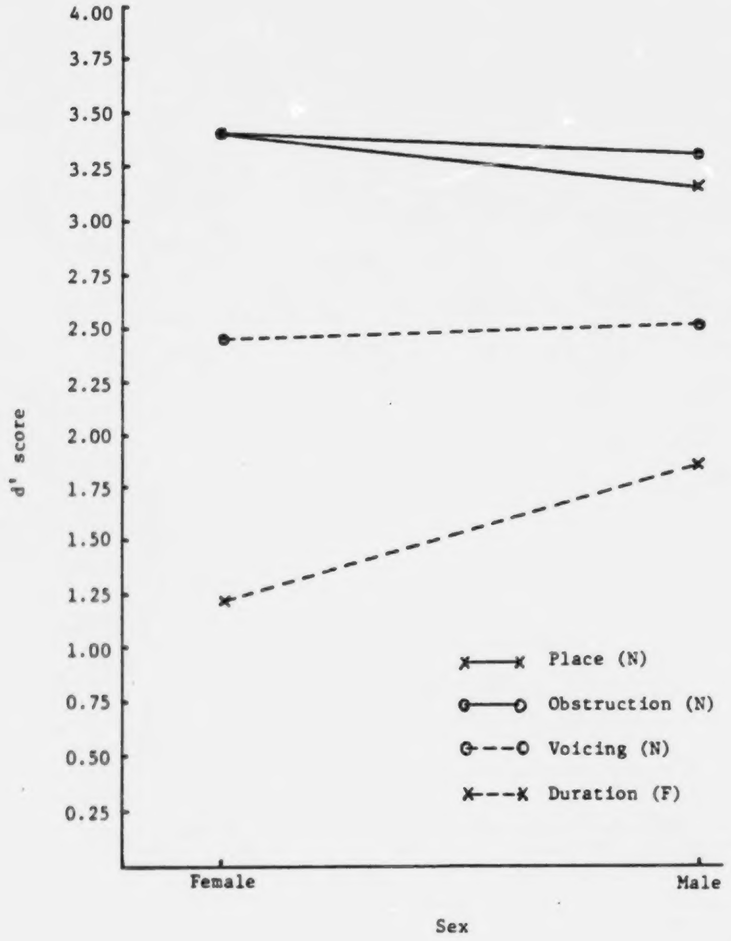


Figure 15: Study 1 - d' scores for discrimination of native or foreign contrasts for males by Age.



Breaking down the sex by contrast interaction, an analysis of the simple effects of contrast for each sex, followed by a comparison of native versus foreign contrasts, showed these to be significantly different from one another for both sexes (Females: F = 151.91, p < .01, Males: F = 58.19, p < .01). As can be seen in both Figures 14 and 15, foreign contrasts are discriminated more poorly than native contrasts. When the sex by contrast interaction was broken down into the simple effects of sex at each contrast level, it was found that only the effect at level 4 (corresponding to the foreign contrast) was significant (F = 7.43, p < .01) (Appendix 5). At that level, males discriminated better than females (see Figure 16). Figure 16 represents a plot of the d' scores for each type of contrast used at the two sex levels. It can be seen that for foreign contrasts males are superior to females.

Figure 16: Study 1 - d' scores for Contrast discrimination by Sex.



Correlation coefficients between the two voicing (native) and duration (foreign) judgments were computed for the 6 - 8 year old group (G2) and for the 10 - 12 year old group (G3). These data are given in Table 1. Table 1 shows the value of the correlations as well as their significance level for the voicing and duration scores on all combinations of the two levels of Age used here

(6 - 8, 10 - 12) with the two levels of Sex (female, male). From inspection of this table, it can be seen that for the 6 - 8 year old group, the correlation between Duration and Voicing was .62, p < .02 for females, .83, p < .000 for males. For the 10 - 12 year old group, it was .59, p < .02 for females, -.03, p < .05 for males.

Table 1:

Study 1. Correlations Between Voicing and Duration Scores by Age and Sex

	Ages			
Sexes	6 - 8		10 - 12	
	Value	Significance level	Value	Significance level
Females	.62	p < .02	.59	p < .02
Males	.83	p < .000	-.03	p > .05

Note. d' scores used.

Correlations for the 4 - 6 year olds and for the 16 - 18 year olds were not computed as the scores here approached floor and ceiling levels respectively.

DISCUSSION

Before addressing the main issues, a few comments are in order. The d' scores rather than the raw scores were used in order to separate the ability of the subject to differentiate between classes of events from motivational effects or response biases. This measure has been found to be applicable to experiments in which the observer's task is to state, after two signal presentations, whether the signals were the same or different (Sorkin, 1962), and has been used by other researchers in speech perception research with a paradigm like the one used here (Cutting, Rosner & Foard, 1976; Pisoni, 1973; Wood, 1976). The hypothesis we were trying to test, namely, within the two-interval same-different paradigm, of processing differences with age as revealed by the developmental pattern in sensitivity (d') scores is not inconsistent with the literature on the types of processing hypothesized to underlie same versus different *judgments* in the two-interval same-different paradigm. Specifically, the types of process giving rise to same judgments and different judgments have been debated. For example, Bamber (1969) claims that one is the result of parallel and the other is the result of serial processing; Krueger (1978) claims that both judgments are based on feature comparisons in a noisy environment. This literature is not inconsistent with our position of an assumed change from piecemeal to configurational processing with age as we define these modes: that is, piecemeal referring to processing done on the basis of relatively simple dimensions, and configurational referring to processing done on the basis of relatively complex dimensions.

The results will be discussed in terms of the questions that we are trying to answer. The first question was: Do there exist two separate processes in the perception of speech? It will be recalled that with faces, upright and inverted faces were equally well categorized at age 6, but that upright faces were much better categorized at age 10 (Carey-Block, 1978). This was taken to reflect

piecemeal processing at age 6, and configurational processing at age 10. In the present study, there was no evidence of change in the native versus foreign processing of speech with age, since the Age by Contrast interaction was not significant. Nevertheless, the *a priori* Age trend analysis for each Contrast revealed a developmental pattern similar to that of face processing with Age; namely, a linear and quadratic component for native speech sounds (similar to upright faces) and a linear component only for foreign speech sounds (similar to inverted faces).

Another potential source of evidence for two separate processes in the perception of speech was the correlation within each Age group between Voicing (Native scores cued by durational cues) and Duration (Foreign scores cued by durational cues). If simple acoustic criteria govern classification at age 6 and before, but linguistic criteria govern such classification at age 10 and after, the correlation between duration and voicing should be high at age 6 and before but low at age 10 and after. In fact, this was found for males but not for females for ages 6 - 8 and 10 - 12. For the latter, the correlation was high for both ages 6 - 8 and 10 - 12. (Such correlations could not meaningfully be done for ages 4 - 6 and 16 - 18 as floor and ceiling effects would have rendered the results non meaningful).

The results of the correlational analyses were not in accord with the patterns for each sex in the *a priori* Age trend analysis for each Contrast. In fact, for the females the linear and quadratic effects were quite strong for the Native contrast, and the linear trend only was present for the foreign contrast. This fits well with a hypothesized piecemeal to configurational shift in processing (see Table 1 and Figure 15).

In the absence of conclusive evidence, that two different processes exist in the perception of speech, the question as to the nature of the two processes becomes irrelevant.

Performance on Duration Contrasts with Age

Improvement in performance on foreign contrasts with Age occurred between the ages 6 - 8 and 10 - 12. This is in marked contrast to findings in the literature whereby foreign contrasts cease to be well discriminated with age or do not improve at all with age (e.g. Werker, Gilbert, Humphrey & Tees, 1981). One possible explanation of the present results is that the foreign contrasts were interpreted as suprasegmental native contrasts, that is, unstressed-stressed VCV's.

Performance on Duration Contrasts with Sex

Males were superior to females in the discrimination of duration but not the native contrasts. This may reflect either a superiority in the discrimination of foreign contrasts or a superiority in the discrimination of suprasegmental contrasts. Although such a superiority, regardless of the interpretation of the stimulus - whether foreign or native suprasegmental -, may be explained by a greater tendency for males toward interaction with peers (Maccoby & Jacklin, 1974), it does not agree with the many findings of superior verbal abilities in females (Maccoby et al., 1974).

CONCLUSION

There are at least two possible reasons why Study 1 did not throw light on the questions posed at the beginning. First, the foreign contrast (Duration) may have been interpreted as a native suprasegmental (unstressed-stressed VCV) by the subjects. Second, ceiling and floor effects may have masked differences between Voicing and Duration contrasts in the age range between 6 - 8 and 10 - 12. In the light of the first point above, we are led to continue to pursue our initial hypotheses with different stimuli; however, in the light of the second point above, we are led into finding another paradigm to answer our questions, as no change in task difficulty could eliminate the double presence of ceiling and floor effects.

NOTE: Some researchers have found the d' (calculated from the formula z(Hit) - z(False Alarm) to be inadequate for use within the two-interval same-different paradigm because it seems to be correlated with the criterion and thus is not an unbiased measure of sensitivity (Macmillan, Kaplan & Creelman, 1977). Kaplan, Macmillan and Creelman (1978) found an appropriate d' (d' for variable-standard discrimination paradigms (including the two-interval same-different paradigm) without the problems inherent in the above (Tables for this statistic are found in the above-mentioned paper). We feel justified, however, in not abandoning the d' statistic (d' = z(Hits) - z(False Alarms)) in the present study for the following reasons. The conclusion to Study 1 was that no light was thrown on the questions posed at the beginning because: a) the foreign contrast (Duration) is also a native, suprasegmental contrast, and may have been interpreted as such by the subjects; b) ceiling and floor effects may mask real differences between Voicing and Duration contrasts in the age range between 6 - 8 and 10 - 12. The first argument a) is totally unaffected by the kind of statistic used. In the case of the second argument b), whatever scores are used, whether d' or d' for variable-standard discrimination paradigms (including the two-interval same-different paradigm), the ceiling and floor effects are maintained.

CHAPTER 3

Study 2: Auditory Versus Phonetic Processes in Loudness and Pitch Judgments of Speech Sounds

INTRODUCTION

This represents our second attempt to answer the experimental questions, using a different paradigm. In Study 1, the same task, that is discrimination of native sounds, was used to assess phonetic versus auditory processing of speech sounds, the assumption being that at younger ages auditory processing would be the most likely mode for processing speech sounds, but that at later ages phonetic processing would be the most likely mode. Our position on this point has changed somewhat. It seems more likely that many tasks call for auditory processing of speech sounds (at whatever ages), and that many other tasks call for phonetic processing of speech sounds (again at whatever ages). Therefore, from now on, we shall attempt to devise tasks that call either for auditory or for phonetic processing of speech sounds. We will maintain our presupposition that speech is a complex stimulus, and that phonetic processing develops somewhere after the ages of 6 - 8, matures even later in males compared to females, and may be influenced differentially by other phonetic systems (that is, other languages) known by the subject. On the other hand, we will suppose that auditory processing has already developed by ages 6 - 8, is equally mature in males compared to females, and may be influenced differently from phonetic processing by other phonetic systems (that is, other languages) known by the subject.

The question as to whether there exist two separate processes in the perception of speech was approached by using a method adapted from a study by Dorman (1974). When adult subjects were asked to discriminate intensity differences in pairs of sounds, different patterns emerged when these sounds were consonants embedded in a CV context as opposed to consonants spliced out of a CV context or steady state vowels. As can be seen in Figure 17, patterns for /bae/, for the isolated formant transitions from /bae/, and for /ae/ are synthesized. Each of the three patterns is made to vary in three ways by utilizing three grades of intensities for the initial 60 msec of the speech sound. The result is that for each stimulus type, the initial 60 msec is either of the same intensity as the remaining 240 msec or is 7.5 or 9.0 dB less intense. Specifically, subjects are presented with a pair of speech sounds *from within a given row* of Figure 17 stimuli and are asked the question: 'Which is louder?' As can be seen in Figure 18, whereas perfect performance was achieved for stops spliced out of speech as well as for steady-state vowels, stops embedded in a CV context produced only chance performance. On this basis it was concluded that performance on the stops in the CV context was a reflection of a 'phonetic' or 'linguistic' mode of processing whereas performance on the stops spliced out of the CV context, as well as performance on the steady state vowels reflected an 'acoustic' mode of processing. This study was an attempt first to replicate Dorman's findings regarding two modes of processing speech sounds. For this, we hoped first to replicate Dorman's exact findings with loudness judgments for stops embedded in a syllabic context as opposed to stops spliced out of their syllabic context. As well, we expected the developmental patterns for the aforementioned stimuli with the aforementioned judgment to differ, whatever that difference might be. We used VCV's instead of CV's.

Next, we attempted to verify Dorman's assumed 'auditory' versus 'phonetic' processing explanation for the differences observed by adding a number of other variables hypothesized to reflect 'auditory' versus 'phonetic' processing differences. First, in addition to loudness judgments for stimuli differing in intensity, we looked for the presence of pitch judgments for stimuli differing in frequency. According to Dorman's interpretation of his findings, the poor intensity discrimination observed for his speech sounds was explained by an unavailability of acoustic cues when operating in the phonetic or linguistic mode. If this interpretation is the correct one, we hypothesized, the same observations should hold for pitch judgments in the case of stimuli

Figure 17: Schematic spectrographic patterns for /bæ/, the isolated formant transitions from /bæ/ and /æ/ with variation in intensities used to test discrimination of intensity differences between speech sounds (enlarged) (Dorman, 1974) (Used by permission)

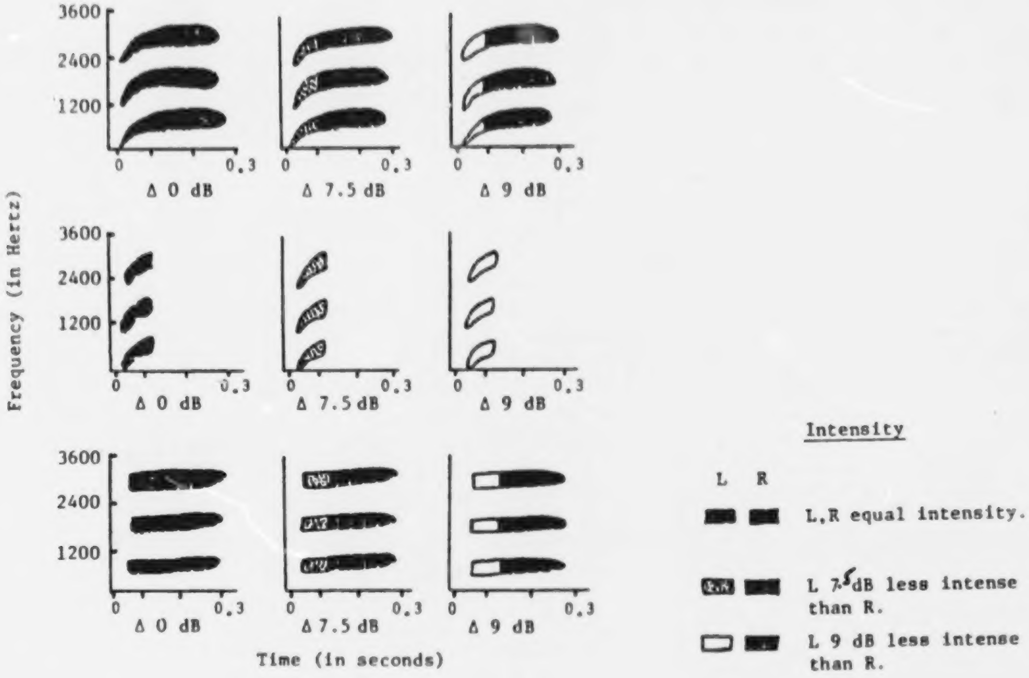
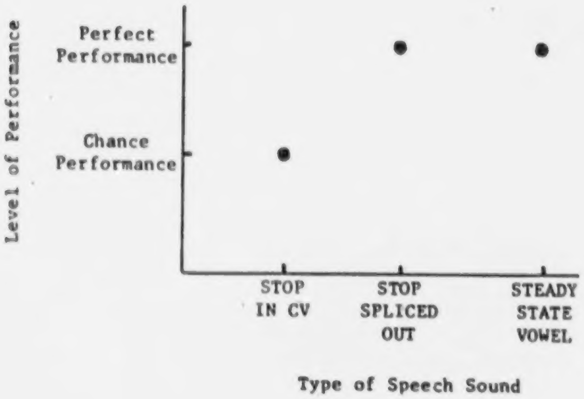

3600
2400
1200
0
0.3
Δ 0 dB
Δ 7.5 dB
Δ 9 dB
Frequency (in Hertz)
Time (in seconds)
Intensity
L R
L, R equal intensity.
L 7.5 dB less intense than R.
L 9 dB less intense than R.

Figure 18: Expected discrimination of intensity differences between stops in and out of their CV context, and between steady state vowels (adapted from Dorman, 1974 findings)

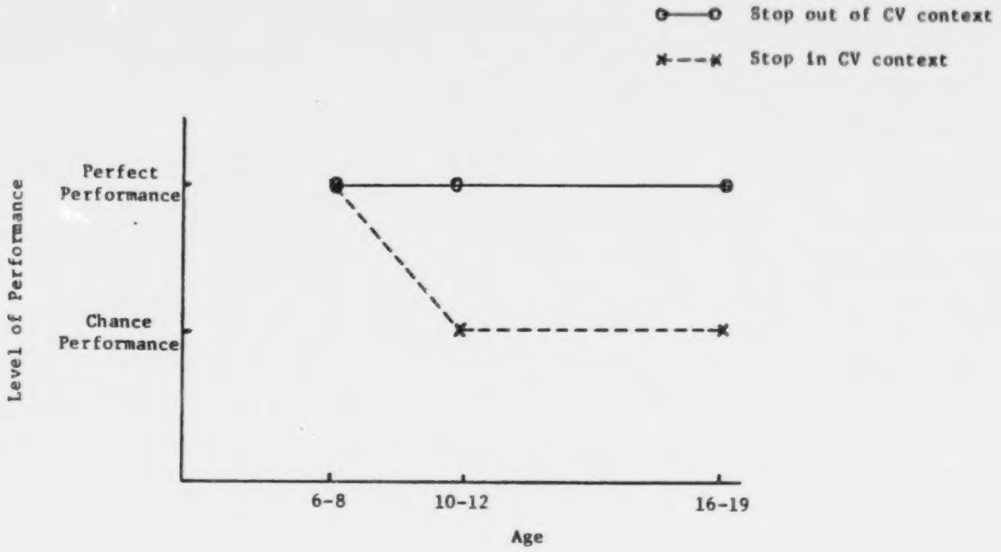


differing in frequency as for loudness judgments in the case of stimuli differing in intensity. Although Dorman's original studies employed the same CV's with differing intensities only, we used VCV's differing in their C by one distinctive feature. Our justification for this is that the same logic should apply, but in a stronger form: if poor intensity discrimination is due to unavailability of acoustic cues when processing linguistically, this should hold, according to us, whether comparing physical differences between two linguistically same sounds or two linguistically different sounds. Second, we examined both stop consonants and fricatives. There are findings in the literature which have led one to postulate that stop consonants are more 'encoded' than fricatives which are more encoded than vowels (Darwin, 1971; Shankweiler & Studdert-Kennedy, 1967). This expression, encodedness, is synonymous, in the literature, with necessitating processing by the phonetic or linguistic mode. As for Dorman's differences between stop consonants and vowels, but somewhat less, it was therefore postulated that Dorman's original differences with loudness judgments for stops embedded in a syllabic context as opposed to stops spliced out of their syllabic context would be much less evident in fricatives than in stop consonants. Hopefully, fricatives embedded in their syllabic context should be performed midway between vowels and stops embedded in their syllabic context: that is, midway between chance and perfect performance. Also, fricatives spliced out of their syllabic context should be performed as well as stops spliced out of their syllabic context, that is perfectly. Third, we hypothesized that if acoustic modes of processing are well developed by age 6 - 8, as postulated before, but that phonetic modes of processing do not reach their full capacity until age 10 or more, on the basis of Dorman's findings and interpretations, the developmental trends shown in Figure 19 should emerge. Discrimination of intensity differences between stops spliced out of their CV context should be perfect at age 6 - 8, 10 - 12, and 16 - 19; discrimination of intensity differences between stops in their CV context should be perfect at age 6 - 8, and then should be at chance level at ages 10 - 12 and 16 - 19. Fourth, we hypothesized that there should be no difference between males and females on developmental trends of indices of acoustic modes of processing but that males should lag somewhat behind females on developmental trends of indices of phonetic modes of processing. More specifically, for males, the dip in performance for stops embedded in their syllabic context shown in Figure 19 should occur somewhat later than age 10 - 12, that is, somewhere between ages 10 - 12 and 16 - 19. Finally, again for reasons to be elaborated upon later on, we expected that knowledge of a second phonetic system (that is, a second language) should influence differentially phonetic versus auditory modes of processing. Since, for the purposes of this study, we did not want to complicate the picture excessively with such differential effects, we decided in advance not to analyze these effects but have all groups contain the whole array of distribution of degree of second-language knowledge.

METHOD

In this study pairs of natural consonants which varied in the intensity and frequency of the consonant cues were presented auditorily to males and females aged 6, 10 and 18 - 19 who each contained the whole range of degree of second-language knowledge from the completely unilingual to the completely bilingual. The consonants were either embedded in a VCV context or were spliced out of that context. The consonants were either stops or fricatives. Subjects had to make loudness and pitch judgments on the consonants. It was hypothesized that at age 18 - 19 loudness judgments for stops would be close to perfect for consonants extracted from speech but would be close to chance levels for consonants within speech. Also it was expected that for loudness judgments in stops there would be a significant difference in the pattern of development across the three age groups for consonants extracted from speech compared to consonants within speech. It was also hypothesized that at age 18 - 19 pitch judgments for stops would be close to perfect for consonants extracted from speech but would be close to chance levels for consonants within speech. Furthermore, at age 18 - 19, it was expected that for loudness judgments, fricatives within speech should be performed at a level midway between chance and perfect levels, but fricatives extracted from speech should be performed perfectly. Finally, for loudness judgments in stops it was expected that both males and females should perform perfectly at all three age groups for consonants extracted from speech. For consonants within speech, it was expected that performance should be close to perfect at age 6 and close to chance levels at age 18 - 19 with the dip in performance occurring somewhat later in males compared to females.

Figure 19: Expected discrimination of intensity differences between stops in and out of their CV context, with age.



Subjects

Subjects were francophones varying in their degree of French/English bilingualism from the completely unilingual to the completely bilingual. In Study 1, only unilingual francophones were used. This proved to be a very tedious and wasteful enterprise in the Montreal areas tested, where about 80% of otherwise potential subjects had to be rejected. As a result, to render matters simpler and less wasteful, within each age and sex group, the whole range of degree of bilingualism was represented, from complete unilingualism to complete bilingualism. This left out the possibly systematic confounding effect of knowledge of a secondary linguistic system on the variables indexing auditory versus phonetic modes of processing. All subjects had a normal auditory history. They came from a private school and a university. They belonged to three age groups: Ages 6, 10, 18 - 19.

Subjects were selected for normal auditory history thus: (this was essentially the same as for Study 1)

1. At ages 6 and 10, a medically negative report was received in terms of problems of audition.
2. At age 18 - 19, subjects had to fulfill certain criteria in their responses to four questions (see Appendix 6 for questions asked and responses required).

Information on the subjects' degree of bilingualism was obtained as follows:

1. An extensive questionnaire on the subject's background, knowledge and use of his language or languages was administered. The questionnaire was a French age-adjusted adaptation of the one used by Vaid and Lambert (1979) (for questionnaire, see Appendix 1), and

2. the reaction time on a color-naming test, used to assess degree of bilingualism (Stroop, 1935 (cited in Lambert, 1969)) (for chart used, and mode of administration, see Appendix 7). This test was used here in preference to the CELT test of English comprehension used in Study 1 because it could be administered to all age groups, and because it was much faster.

The information thus obtained was used to rank subjects on their degree of bilingualism, from the completely unilingual to the completely bilingual and then, within each age and sex group, have a selection of subjects representing the whole range of degrees of bilingualism.

The number of subjects by age and sex were:

six male and six female children age 6 (female mean = six years, nine months, male mean = six years, 10 months);

six male and six female children age 10 (female mean = 10 years, nine months, male mean = 10 years, eight months);

six male and six female adults age 18 - 19 (female mean = 18 years, eight months, male mean = 19 years, one month).

Subjects came from the following institutions in Montreal:

1. At ages 6 and 10, they came from Collège Stanislas (a private institution),
2. At age 18 - 19, they came from McGill University.

Stimuli

Rationale for choice of stimuli

Dorman used pairs of synthetic stimuli from the same phonetic category (i.e. bae - bae) which varied *only* in intensity. This study used pairs of natural stimuli from different phonetic categories (i.e. afa - ava) which varied both in their linguistic belongingness and in their correlated physical characteristics. Theoretically, this should produce no difference in results. If the physical parameters of the stimuli are unavailable due to linguistic coding, this should be so with both sets of stimuli.

For diverse reasons, we had to make three categories of assumptions throughout this study. They are assumptions regarding the cues used by the listener for the identification of the stimuli, assumptions regarding the acoustic properties of the stimuli, and assumptions regarding the perceived pitch and loudness of the stimuli. We shall describe each set of assumptions below.

Assumptions regarding the cues utilized by the listener for the identification of the stimuli

The first assumption is that listeners use the same cues to identify consonants extracted from speech as to identify consonants embedded in speech. This assumption encounters problems in its justification. As a matter of fact, cues for consonants surrounded by vowels are often located in the adjacent vowels. The second assumption regards the particular cues the listener will focus on to identify the consonants. For the p/b distinction these would be two cues, the duration of closure, long duration for 'p', short duration for 'b', and the presence of the burst, strong for 'p', weaker for 'b'. For the f/v distinction these would also be two cues, the duration of constriction, long for 'f', short duration for 'v', and the presence of energy below 1000 Hz, none for 'f', yes for 'v' (Ling, 1976). This assumption is in great measure justified as these cues are the most frequently cited cues for these consonant contrasts in the literature.

Assumptions regarding the acoustic properties of the stimuli

As can be seen in Figure 20, the first assumption is that the voiced consonants /b/ and /v/ in intervocalic position are, on the average, more intense than their unvoiced counterparts /p/ and /f/. The main reason for this is that the closure duration for the unvoiced consonant in a medial position is greater than that for the voiced consonant (Ling, 1976). As can be seen in Figures 21a and 21b, the voiced consonants /b/ and /v/ in intervocalic position, have on the average, more low frequency components than their unvoiced counterparts /p/ and /f/. The main reason for this is that low-frequency components in unvoiced consonants are either less prolonged or much less present. In stops, they are in fact less prolonged, and the high frequency components are more present. In fricatives, they are much less present (Ling, 1976). In the adjoining figures spectrograms of the consonants spliced out of speech have also been presented since these effects are sometimes better observed there.

Figure 20: **Study 2. Amplitude envelopes of consonants within speech**

Note. All four abscissae and all four ordinates are partitioned similarly.

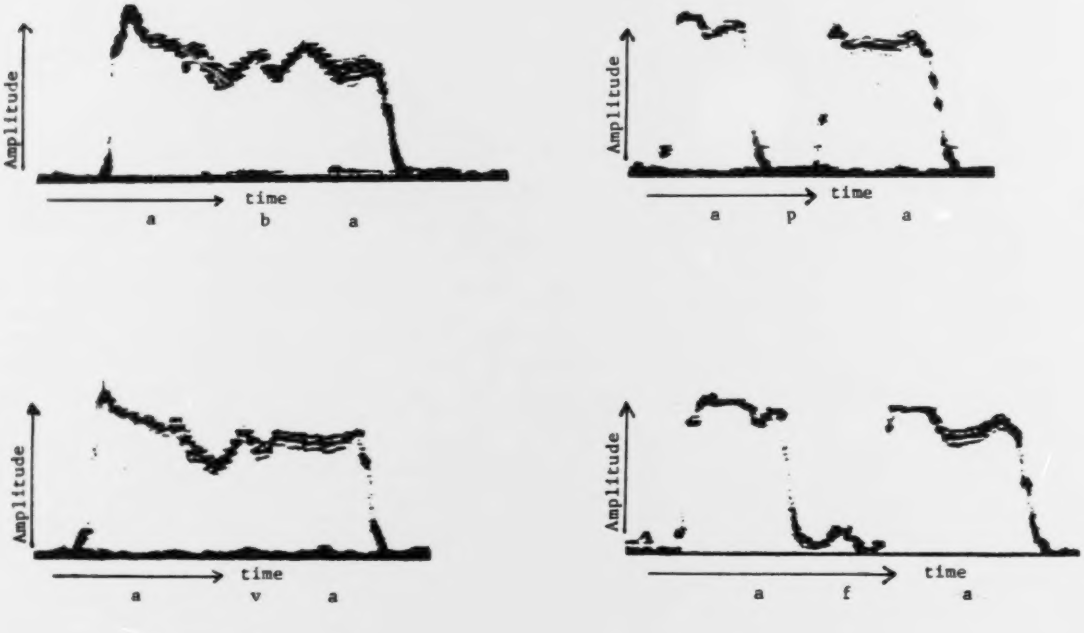


Figure 21a: **Study 2. Spectrograms of consonants within speech and consonants extracted from speech: stops.**

Note. All four abscissae and all four ordinates are partitioned similarly.

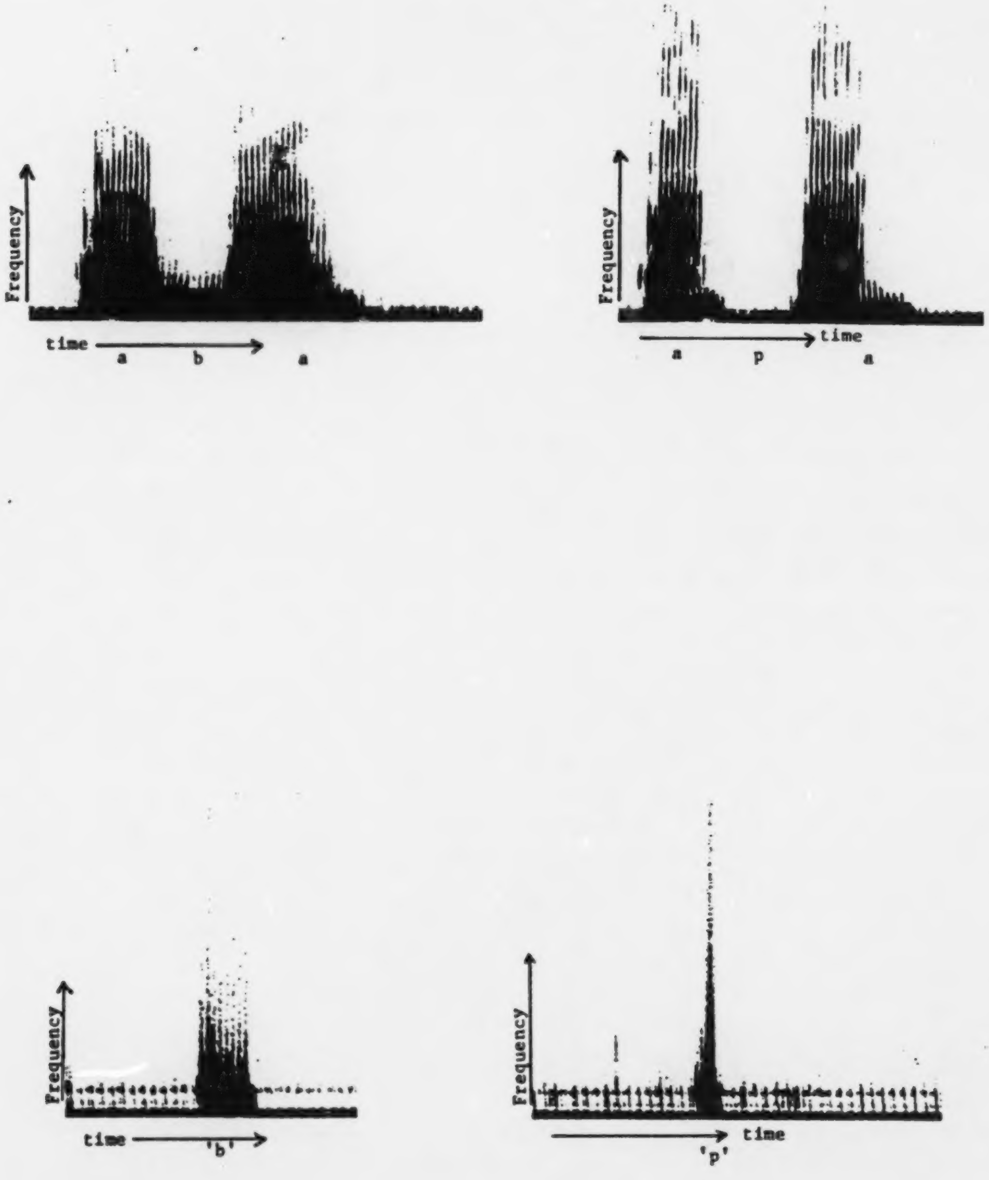
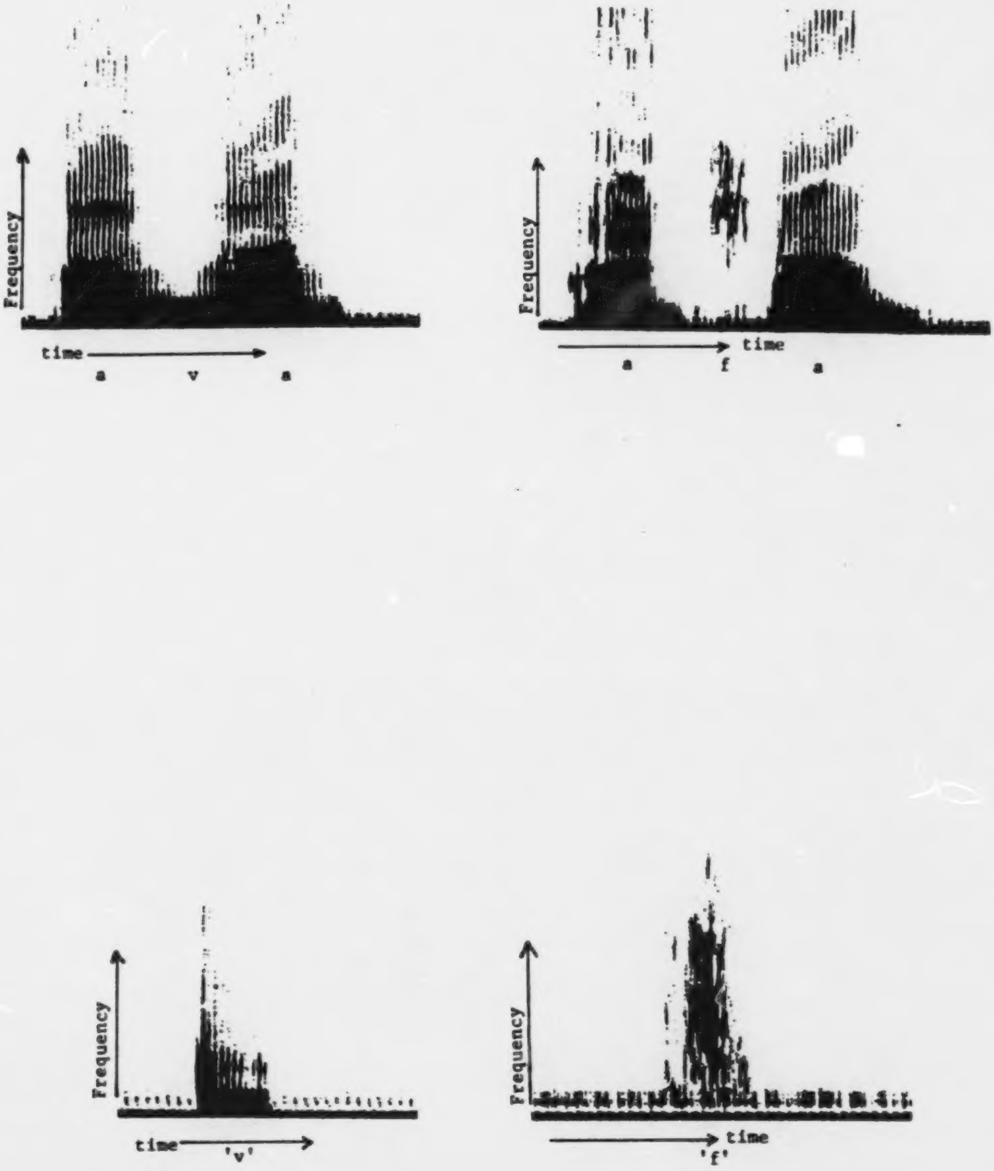


Figure 21b: Study 2. Spectrograms of consonants within speech and consonants extracted from speech: fricatives.

Note. All four abscissae and all four ordinates are partitioned similarly.



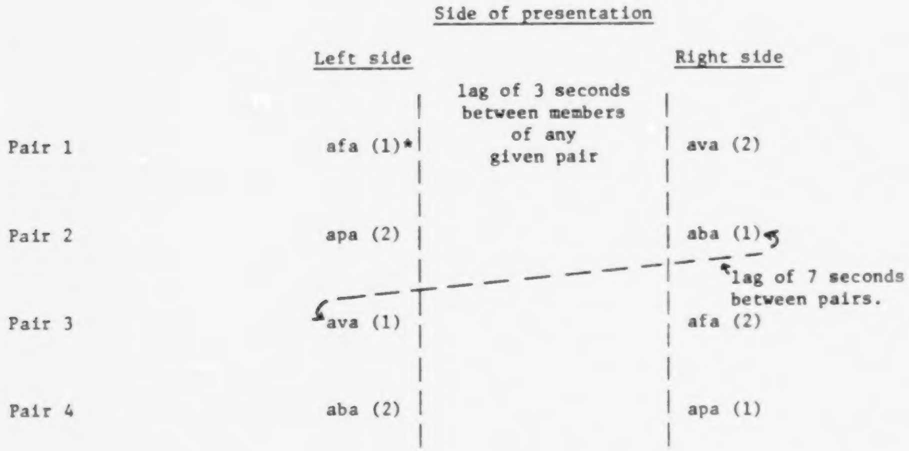
Assumptions regarding the perceived pitch and loudness of the stimuli

The first assumption is that speakers utilize the same rules to assign pitch and loudness to consonants extracted from speech as to consonants embedded in speech. There is reason to view this assumption with caution. The reason for such caution is that the cues utilized in the two contexts may differ and also the fact that pitch and loudness judgments have been shown to be sensitive to durational differences in the stimuli, to give one example (Moore, 1977). The second assumption regards the basis for judging one stimulus as higher pitched or louder than another. As regards pitch, the main difficulty in this context is that the pairs of stimuli chosen differ mainly along qualitatively different dimensions. More specifically, the voiced consonants 'b' and 'v', have as their main acoustic cue the presence of relatively low frequency periodic energy. On the other hand, the voiceless consonants 'p' and 'f', have as their main acoustic cue the presence of relatively high and widespread-frequency aperiodic energy. This presents a problem because most studies on pitch perception have used periodic sounds and none have compared the relative pitch of periodic versus aperiodic sounds. We have based our decision on the relative pitch of the two sounds on the following rationale. For the p/b distinction, we will consider the main positive cue for 'b' to be the presence of voicing. (To be sure there are other cues, such as the duration of the preceding vowel, as well as the duration of closure, but to render matters somewhat less complex, we have focused only on one important cue for the moment). This cue corresponds to low frequency periodic energy. In a similar fashion, the main positive cue for 'p' is the presence of the burst (see Figure 21a). This corresponds to aperiodic energy spread over all frequencies. For periodic sounds, the pitch corresponds in general to that of the fundamental of the harmonic complex (Moore, 1977). On the other hand, according to Ladefoged (1962), if you compare two sounds with aperiodic energy spread over a wide range of frequencies, that sound whose component frequencies are of relatively greater amplitude over the higher frequencies will be heard as the higher-pitched of the two. Combining these two theories, it is hypothesized that 'p' will be perceived as higher-pitched than 'b'. For the f/v distinction, the main positive cue for 'v' is the presence of voicing. This corresponds to low-frequency periodic energy. The main positive cue for 'f' is the presence of mid- to high-frequency frication (see Figure 21b). This corresponds to aperiodic energy spread over mid- to high-frequencies. As a result, for the same reasons as those cited for the p/b distinction, it is hypothesized that 'f' will be perceived as higher-pitched than 'v'. As regards loudness, one of the main difficulties in this context is that theorists disagree as to how the energy from the various frequencies add up to yield a given measure of loudness for any given complex sound. Loudness of complex sounds seems to be affected by many factors, such as degree of spread of frequency, duration of the stimulus, the range of stimuli presented, etc. (Moore, 1977). We have arbitrarily decided to assign a loudness level on the basis of the sum of the individual energies at each frequency level. On that basis, then, for the p/b distinction, 'b' is louder than 'p', and for the f/v distinction, 'v' is louder than 'f' (see Figure 20). (We should note that such a conclusion may appear to contradict some of the assertions in some of the traditional linguistic literature (see for example Landercy & Renard, 1977) where for example p is judged to be more intense than b. The main reason behind such a contradiction lies in a different weighting of the findings in the literature -- the latter for example, assigning more weight to the fact that sounds of low frequency (such as those in b) are in general perceived as weaker (for any given intensity level) than those of high frequency (such as those in p). However, until more evidence on the nature of loudness perception in complex sounds (and in speech sounds in particular) is gathered, it is difficult to say which approach --if a choice must be made -- reflects more the perceiver's reality.

Arrangement of stimuli on tape

The source of all stimuli were a number of VCV's derived from the original list taped by the male Hungarian speaker in Study 1. They were four in all. These were, one apa, one aba, one afa, and one ava. The stimuli were either used as such or the consonant was extracted from its vocalic context (see Figure 21a and 21b for resulting spectrograms). Stimuli used as such will thereafter be called consonants within speech, and stimuli in which the consonant was extracted from its vocalic context will thereafter be called consonants extracted from speech. The stimuli were recorded on tape in the following manner. For the Consonants within speech, these were transferred from the tape made for Study 1 onto a new tape for use in a pilot study. Tape recorders used for this purpose were SONY Stereo Tape Recorder TC-200, Serial No. 145012 and No. 209220. Tapes used were 1.5 mil., polyester low noise tapes. The speed of the recording was 3.75 inches per second. These were then removed and spliced onto a new tape. Tape recorders used for this purpose were SONY Stereo Tape Recorder TC-200, Serial No. 145012, and SONY Stereo Tape Recorder TC-200, Serial No. 209220; the tape used was 1.5 mil., low noise polyester tape. The speed of the recording was 3.75 inches per second. For the Consonants extracted from speech, these were first transferred from the tape made for Study 1 onto a new tape in the form of VCV's. The tape recorders used were the SONY Stereo Tape Recorder TC-200, Serial No. 145012 and No. 209220. The tapes used were 1.5 mil., polyester low noise tapes. The speed of the recording was 3.75 inches per second. The "C"s were then spliced out for use in a pilot study. The "C"s thus prepared were transferred onto a new tape. The tape recorders used were the SONY Stereo Tape Recorder TC-200, Serial No. 145012, and the SONY Stereo Tape Recorder TC-200, Serial No. 209220. The tape used was 1.5 mil., low noise polyester tape. The speed of the recording was 3.75 inches per second. There were two types of stimulus presentations, one involved the consonants within speech, the other involved the consonants extracted from speech. For the presentation involving the consonants within speech, pairs of VCV's were presented, one coming through one amplifier, recorded on one track of the tape, and the other coming through the other amplifier after a short lag, recorded on the other track of the tape. As will be elaborated in the Procedure section, one amplifier was to the left, the other was to the right of the subject. Members of the pair of VCV's differed from one another by the voicing feature of the consonant. The pairs of VCV's are apa/aba and afa/ava. For the presentation involving the consonants extracted from speech, the "C"s extracted from their VCV context were used. Again, as above, one "C" comes out through one amplifier, being recorded on one track of the tape, the other "C" comes out through the other amplifier after a short lag, being recorded on the other track of the tape. Again, one amplifier was to the left, the other was to the right of the subject. Also, members of the pair of "C"s differed from one another by the voicing feature of the consonant. The pairs of "C"s are 'p'/'b', and 'f'/'v'. Figure 22 presents the arrangement of consonants within speech as they were heard by the subjects in terms of time of presentation and side of presentation. Figure 23 presents the arrangement of consonants extracted from speech as they were heard by the subjects also in terms of time of presentation and side of presentation.

Figure 22. **Study 2. Consonants within speech as taped and heard by subjects**



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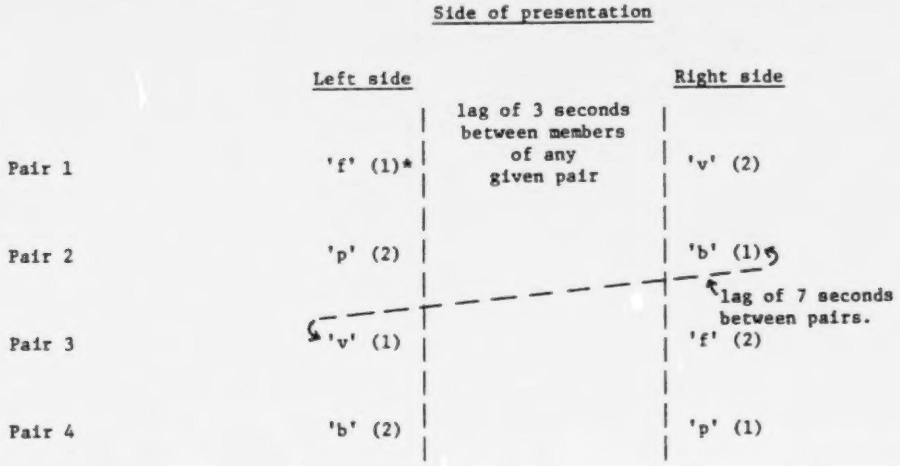
* — order of appearance within a pair.

Figure 23: **Study 2. Consonants extracted from speech as taped and heard by subjects**



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* — order of appearance within a pair.

Procedure

The experiment was conducted in a quiet room within the school, for ages 6 and 10, or university, for age 18 - 19. Testing was conducted by a female francophone assistant. She was blind to the actual purpose of the study, having been told only that the experiment was on language acquisition.

The apparatus consisted of a tape recorder (a SONY TC-200, Serial No. 145012) with its two loudspeakers. The tape recorder was placed in such a way so as to face the blind assistant. The loudspeakers were each connected to one channel of the tape recorder, the left speaker being connected to channel 1, the right speaker being connected to channel 2. The speakers were placed each at a 60° angle to the side of the table facing the subject's chair. The listening level was preset by the experimenter so as to be at a comfortable level. Also, it was preset by the experimenter so as to yield nearly identical spectrographic profiles for given consonants, whatever would be the type of presentation, whether consonant within speech or consonant extracted from speech, and whatever would be the side of presentation, whether the left side or the right side.

On the right side of the tape recorder, or alternately on the assistant's lap, subjects' response sheets were located. The experimenter's chair was placed so as to be back to back with the subject (see Appendix 8). The setting was arranged in such a way that the blind assistant was the only one who interacted with the subject *within* any experimental condition, and, since the response measure of the subject was to *point* to one or the other loudspeaker, the experimenter never knew if the subject had answered correctly or not.

Subjects heard the tape twice, once for loudness judgments, once for pitch judgments. There were four conditions in all consisting of all possible combinations of Type of Stimulus, whether Consonant within Speech or Consonant extracted from Speech, and of Type of Judgment, whether Pitch Judgment or Loudness Judgment. The resulting four conditions are as follows: 1. Consonant within Speech, Pitch Judgment, 2. Consonant within Speech, Loudness Judgment, 3. Consonant extracted from Speech, Pitch Judgment, 4. Consonant extracted from Speech, Loudness Judgment. Before each condition they were given, by the experimenter, the appropriate instructions. These are described below.

After being brought into the Experimental Room by the experimenter, subjects were instructed as follows. For the condition Consonant within Speech, Pitch Judgment, they were first instructed to acquaint themselves with what they would hear and how to focus on the middle letter, and then instructed to discriminate pitch differences between the two pairs of middle letters. For the condition Consonant within Speech, Loudness Judgment, they were first instructed to acquaint themselves with what they would hear and how to focus on the middle letter, and then instructed to discriminate loudness differences between the two pairs of middle letters. For the condition Consonant extracted from Speech, Pitch Judgment, they were first instructed to acquaint themselves with what they would hear and how to focus on the middle letter, and, then instructed to discriminate pitch differences between the two pairs of middle letters. For the condition Consonant extracted from Speech, Loudness Judgment, they were first instructed to acquaint themselves with what they would hear and how to focus on the middle letter, and then instructed to discriminate loudness differences between the two pairs of middle letters (see Appendix 9 for complete instructions).

The experimenter then sat with her back to the child (see Appendix 8) and the blind assistant had the task of manipulating the tape recorder to present each pair of stimuli. Before each pair, the blind assistant repeated the appropriate instruction. For the condition Consonant within Speech, Pitch Judgment, the instruction was: "Now point to the one which has the higher middle letter (or sound)". For the condition Consonant within Speech, Loudness Judgment, the instruction was: "Now point to the one which has the louder middle letter (or sound)". For the condition Consonant extracted from Speech, Pitch Judgment, the instruction was: "Now point to the one which is higher". For the condition Consonant extracted from Speech, Loudness Judgment, the instruction was: "Now point to the one which is louder".

After each pair, the tape recorder was stopped and the subject was given the time to answer or ask for a replay. If the subject was silent for 30 seconds, the blind assistant spontaneously said she would replay the stimuli.

After completing the stimuli within the given condition, the experimenter got up, faced the subject and told him/her that he/she had done very well. She then went on to the other of the instructions appropriate to the next condition and the cycle was repeated. This was done until all four conditions had been completed.

The whole procedure, from start to finish, took about 15 minutes. The blind assistant recorded the subject's responses, as Left or Right side (see Appendix 10).

DESIGN

There were three age groups (age 6, 10, 18 - 19) and two sexes (male, female), with six subjects nested within each of these age-sex cells. The subject was to point to the 'higher' or 'louder' consonant, as requested. The dependent variable was percent correct for each type of consonant (fricative or stop) within each type of judgment (loudness, pitch), and within each type of stimulus (Consonant within Speech, Consonant extracted from Speech). See Appendix 11 for the complete design.

The analysis was a five-way ANOVA with repeated measures on three factors. This consisted of three levels of age (A) (Ages 6, 10, 18 - 19), two levels of sex (X), and six subjects nested within each age-sex combination. The repeated factors were: Type of Judgment (J), which consisted of two levels, Loudness and Pitch; Type of Stimulus (S_t) which consisted of two levels, Consonant within Speech and Consonant extracted from Speech; and Type of Consonant (C), which consisted of two levels, Fricative and Stop. The factors not analyzed for were the order of judgments (counterbalanced), the order of type of stimulus (counterbalanced), the order of voicing within each type of Consonant (counterbalanced), the side of the first stimulus (left or right) (this factor was inadvertently confounded with the type of consonant factor), and the order of type of consonant (this was fixed at fricative then stop).

RESULTS

A complete tabular description of results done on the basis of the Analysis of Variance of the data can be found in Appendix 12. All expected results were tested within the Analysis of Variance. There was a significant main effect for Type of Stimulus ($F = 14.3862$ with 1, 30 df., $p < .01$). There were also significant two-way interactions of Type of Judgment by Type of Stimulus ($F = 28.6139$ with 1, 30 df, $p < .01$), Type of Judgment by Type of Consonant ($F = 17.6991$ with 1, 30 df., $p < .01$), and Type of Stimulus by Type of Consonant ($F = 15.4217$ with 1, 30 df., $p < .01$), and significant three-way interactions of Age by Type of Judgment by Type of Stimulus ($F = 4.3317$ with 2, 30 df., $p < .05$), and Type of Judgment by Type of Stimulus by Type of Consonant ($F = 5.5505$ with 1, 30 df., $p < .05$). None of the higher interactions were significant. All main effects and all two-way interactions will be interpreted within the higher order three-way interactions (see Figures 24 and 25. Figure 24 represents a plot of the percent correct scores for each type of Stimulus level and each type of Judgment level used at the three Age levels employed. Figure 25 represents a plot of the percent correct scores for each type of Stimulus level and each type of Judgment level used for the two types of Consonants employed.).

Figure 24: Study 2. Three-way interaction of age by type of judgment by type of stimulus.

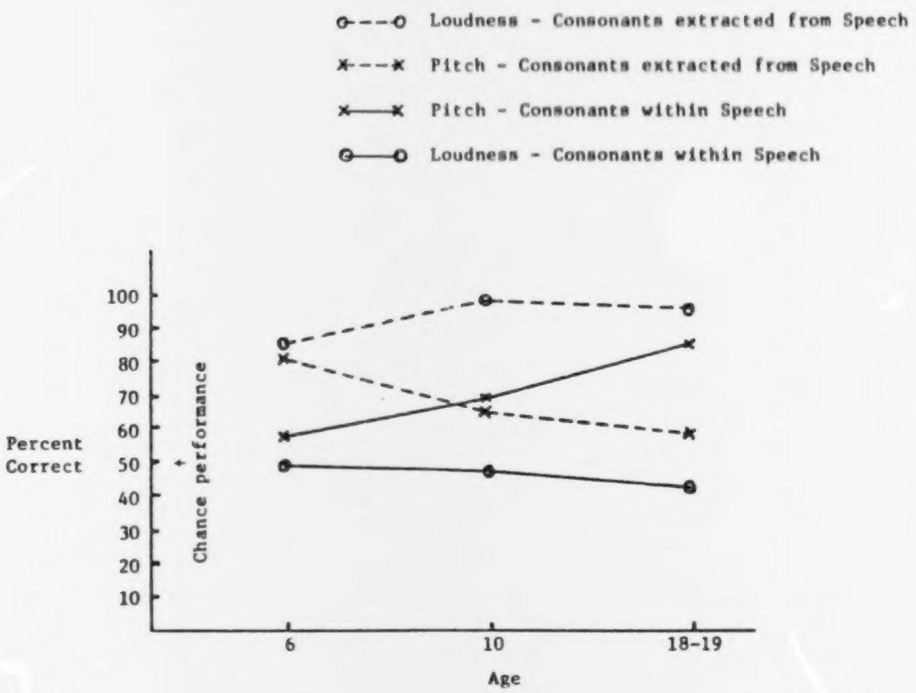
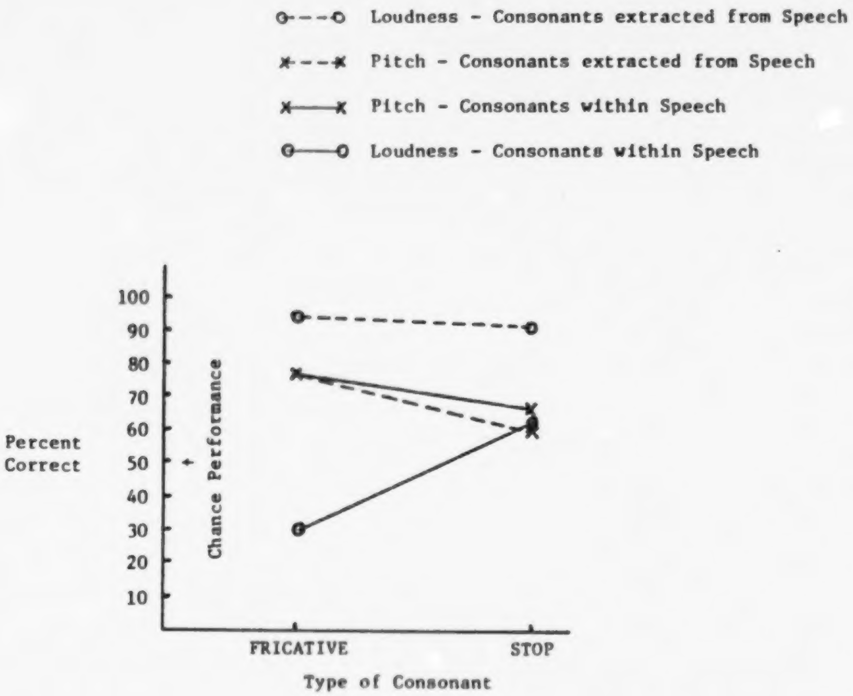
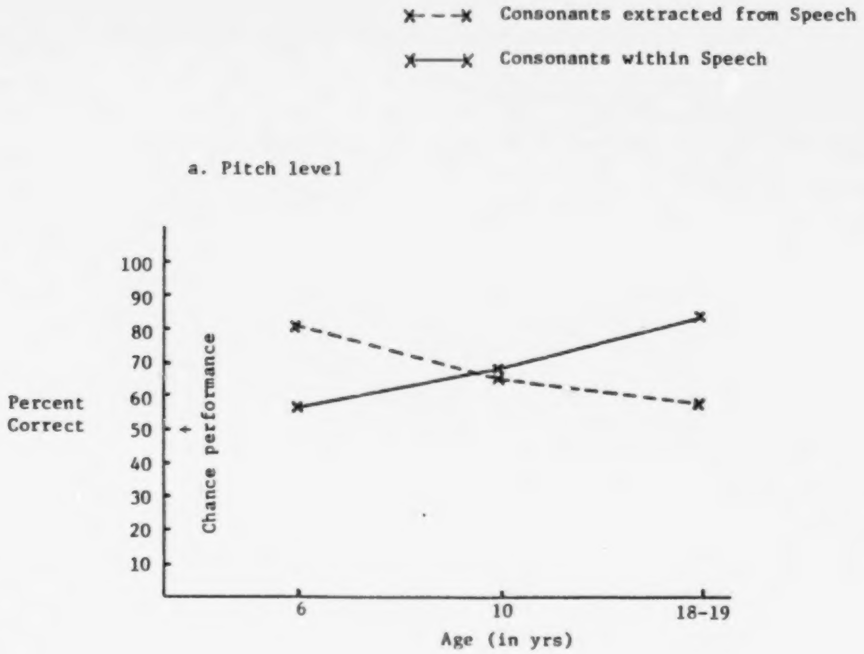


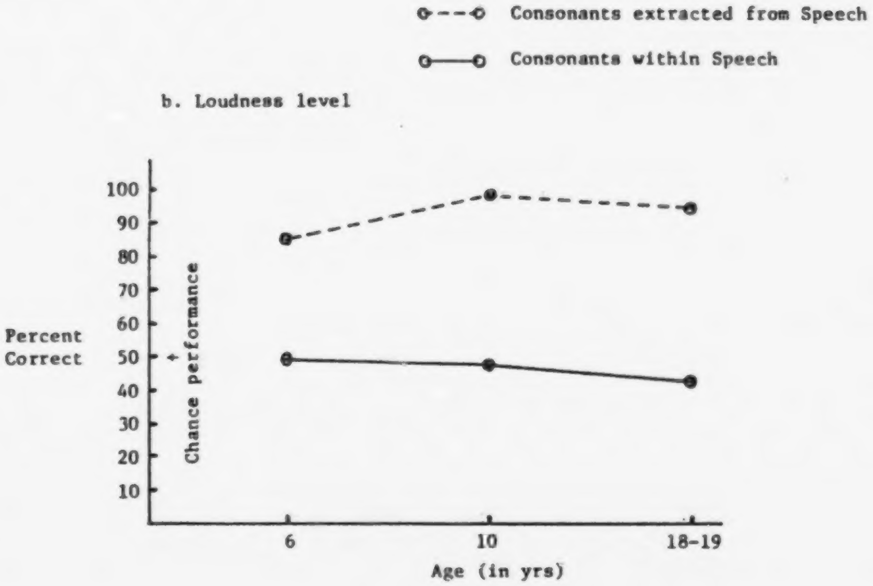
Figure 25: Study 2. Three-way interaction of type of judgment by type of stimulus by type of consonant.



Breaking down the Age by Type of Judgment by Type of Stimulus interaction, an analysis of the simple interaction effect of Age by type of Stimulus at each type of Judgment level revealed the following trends: for pitch judgments, performance seemed to be close to chance level (50% correct) at age 6 and to improve gradually all the way to close to perfect level (100% correct) at age 18 - 19, for consonants within speech; for consonants extracted from speech, performance seemed to be close to perfect level at age 6 and to deteriorate gradually all the way to close to chance level at age 18 - 19. For loudness judgments, performance seemed to be close to chance levels at all three age levels for consonants within speech; for consonants extracted from speech, performance seemed to be close to perfect levels at all three age levels. That interaction was significant for pitch judgments ($F = 3.722$ with 2, 57 df., $p < .05$) but was not significant for loudness judgments ($F = 0.4571$ with 2, 57 df., $p > .05$) (see Figure 26 and Appendix 12. Figure 26 represents a plot of the percent correct scores for each type of Stimulus level at the three Age levels employed, for a. Pitch, and for b. Loudness.). The simple interaction effect of Age by Type of Stimulus for Pitch Judgments was further analyzed to examine the simple effect of Type of Stimulus at each of the three Age levels employed. This revealed the following trends: for the six year olds, performance seemed to be close to chance levels for consonants within speech compared to close to perfect for consonants extracted from speech; for ten year olds, performance seemed to be close to chance levels both for consonants within speech and for consonants extracted from speech; for eighteen to nineteen year olds, performance seemed to be close to perfect for consonants within speech and close to chance levels for consonants extracted from speech. It was found that that simple interaction effect was not significant for the six years olds ($F = 3.386$ with 1, 57 df., $p > .05$) or for the ten year olds ($F = 0.112$ with 1, 57 df., $p > .05$) but was significant for the eighteen-nineteen year old group ($F = 4.03$ with 1, 57 df., $p < .05$). The simple interaction effect of Age by Type of Stimulus for Loudness judgments was further broken down into the simple main effects of Age and Type of Stimulus for Loudness judgments. This revealed the

Figure 26: Study 2. Simple interaction effects of age by type of stimulus at each type of judgment level: a. Pitch level, and b. Loudness level.


a. Pitch level


b. Loudness level

following trends: with respect to Age, there did not seem to be performance differences across the three different Age levels whether for consonants within speech, which ways always close to chance levels, or for consonants extracted from speech, which was always close to perfect; with respect to Type of Stimulus, across the three different Age levels consonants extracted from speech seemed always to be performed close to perfect and consonants within speech seemed always to be performed close to chance levels. It was found that the simple main effect of Age for Loudness judgments was not significant ($F = 0.295$ with 2, 60 df., $p > .05$), but that the simple main effect of Type of Stimulus for Loudness judgments was significant ($F = 42.59$ with 2, 57 df., $p < .01$).

Breaking down the Type of Judgment by Type of Stimulus by Type of Consonant interaction, an analysis of the simple interaction effect of Type of Stimulus by Type of Consonant at each Judgment level revealed that that interaction was not significant for pitch judgments ($F = 0.651$ with 1, 47 df., $p > .05$) but was significant for loudness judgments ($F = 18.98$ with 1, 47 df., $p < .01$) (see Figure 27 and Appendix 12. Figure 27 represents a plot of the percent correct scores for each type of Stimulus level at the two types of Consonant levels employed for a. Pitch, and for b. Loudness). The simple interaction effect of Type of Stimulus by Type of Consonant for Loudness judgments was further analyzed to examine the simple simple main effect of Type of Consonant at each of the two Types of Stimulus levels employed. This revealed the following trends: for consonants within speech, fricatives seemed to be performed well below chance levels whereas stops seemed to be performed close to chance levels; for consonants extracted from speech, both fricatives and stops seemed to be performed close to perfect levels. It was found that that simple simple main effect was significant for consonants within speech ($F = 27.17$ with 1, 118 df., $p < .01$) but was not significant for consonants extracted from speech ($F = 0.425$ with 1, 118 df., $p > .05$).

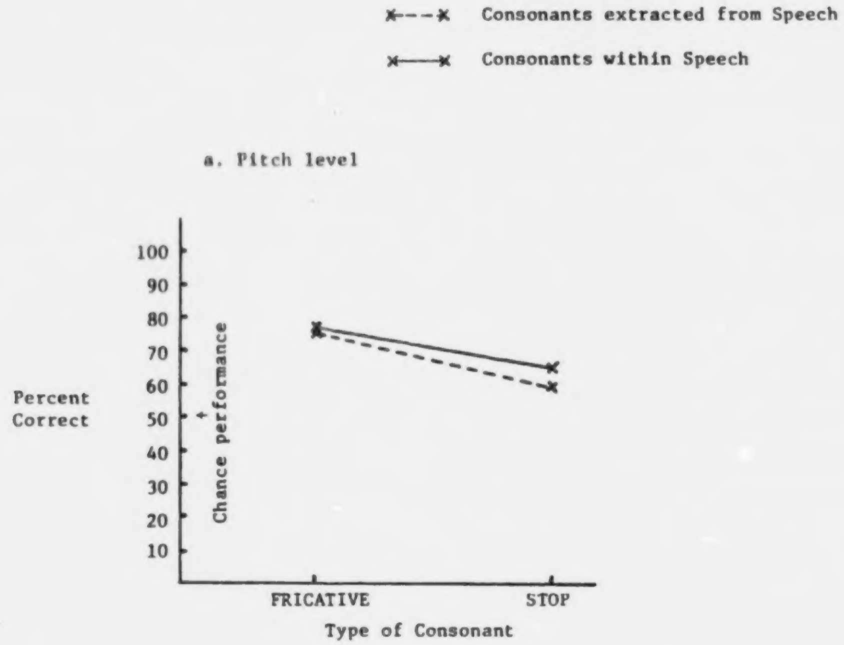
DISCUSSION

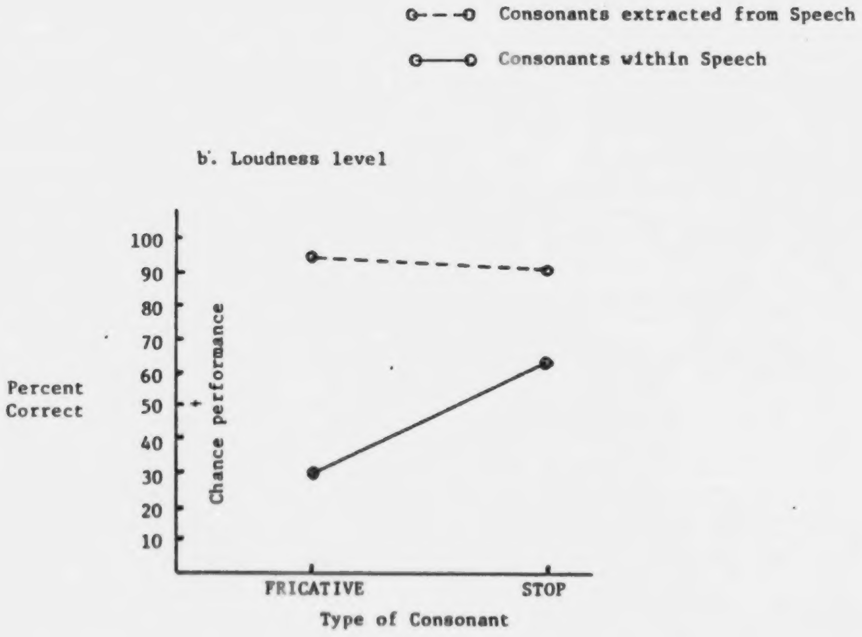
The results will be discussed in terms of the two questions that we are trying to answer.

The first question was: Do there exist two separate processes in the perception of speech? It will be recalled that with synthetic speech sounds, perfect discrimination of intensity differences was achieved in adults for stops spliced out of speech, but stops embedded in a CV context produced only chance performance (Dorman, 1974). This was taken to reflect a 'phonetic' or 'linguistic' mode of processing for stops in the CV context, but an 'acoustic' mode of processing for stops spliced out of the CV context. The first important finding of the present study, that discrimination of loudness differences in adults was perfect for stop consonants extracted from speech but at chance level for stop consonants within speech confirms Dorman's original findings. Nevertheless, we did not find, as we hoped, any differences in the patterns of development for the discrimination of loudness differences for stop consonants within speech compared to stop consonants extracted from speech. We thus have one piece of evidence out of a possibility of two that there may exist two different processes in dealing with speech stimuli.

The second question was: Is one process 'auditory' , and the other 'phonetic'? Discrimination of pitch differences for stop consonants by adults which theoretically should follow the same pattern as for loudness, showed in fact the reverse pattern, much better discrimination for stop consonants within speech than for those extracted from speech. We also expected to find Dorman's findings with stop consonants replicated, but less strongly for fricatives which are presumably less encoded linguistically. Specifically, we expected loudness judgments for fricatives extracted from speech to be perfect, just as for stop consonants. However, we expected loudness judgments for fricatives within speech to be performed midway between chance and perfect levels. In fact, loudness judgments for fricatives extracted from speech were, like stop consonants extracted from speech, performed close to perfect levels. Nevertheless, loudness judgments for fricatives within speech were performed midway between chance and zero level performance. This was much more poorly than similar judgments for stops in speech which were close to the expected chance levels. The most probable reason for this unexpected finding is a lack of perfect matching in length and amplitude of the surrounding vowels for stimuli within the pair to be judged. As can be seen in

Figure 27: Study 2. Simple interaction effect of type of stimulus by type of consonant at each judgment level: a. Pitch level, and b. Loudness level.





Figures 28a and 28b, whereas for the stops, the length and amplitude of the vowels are about equal for apa and aba, they are strikingly unequal for afa and ava. Furthermore, the inequality is in the 'wrong' direction: that is, for judgments of loudness, afa contains the more intense and longer vowels, but ava contains the louder consonant. Finally, we expected to find specific patterns of development for presumed auditory versus phonetic processing of loudness judgments for stop consonants within speech and stop consonants extracted from speech and some differences in those specific patterns with the sex of the subjects. In fact, no significant sex differences in those patterns were observed. As for the developmental patterns, they were as expected for the presumed 'auditory' process. That is, loudness judgments for stop consonants extracted from speech were close to perfect levels for all three age groups observed, age 6, 10, and 18 - 19. Nevertheless, for the presumed 'linguistic' process, we did not find the expected developmental dip in performance from close to perfect levels at age 6 to close to chance levels somewhere between age 6 and age 18 - 19. In fact, for all three age groups observed, performance remained close to chance levels. We thus cannot yet claim to have good evidence for the existence of auditory versus phonetic processes although some of our predictions were in fact met.

Our findings to date therefore seem to provide some support for the distinction between two modes of processing speech sounds although the evidence favoring a particular 'phonetic' versus a particular 'auditory' mode is not here strongly sustained. Other researchers, working with other ramifications of Dorman's (1974) paradigm, have since reached similar conclusions regarding the 'auditory'/'phonetic' processing distinction. Pastore, Ahroon, Wolz, Puleo, and Berger (1975) reached that conclusion because they replicated the phenomenon observed by Dorman (1974) but using pure-tone stimuli analogous to Dorman's speech stimuli.

CONCLUSION

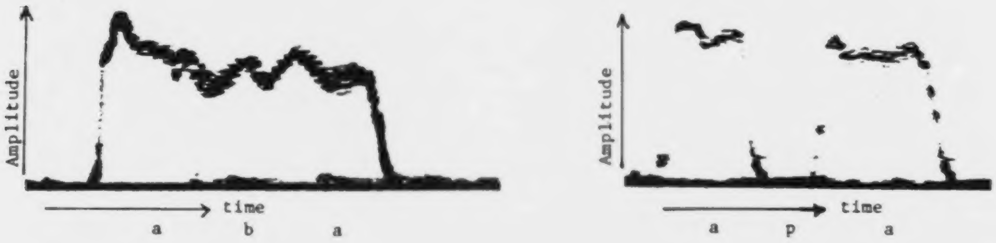
It will be recalled that a number of assumptions governed the criteria on which the dependent variable was measured. Some of these assumptions encounter problems for their justification. Within the assumptions regarding the cues utilized by the listener for the identification of the stimuli, the assumption that listeners use the same cues to identify consonants extracted from speech as to identify consonants embedded in speech is problematic. Within the assumptions regarding the perceived pitch and loudness of the stimuli the assumption that speakers utilize the same rules to assign pitch and loudness to consonants extracted from speech as to consonants embedded in speech and the basis for judging one stimulus as higher pitched or louder than another are also problematic. As a result, all findings based on the above assumptions have to be interpreted with caution.

Study 2 replicated an original finding leading to the hypothesis that there existed two separate processes in the perception of speech. It will be recalled that no such evidence could be mustered on the basis of Study 1. This finding is, within this thesis, the first piece of suggestive evidence for two separate processes. Furthermore, although we did get the expected developmental trend for the presumed 'auditory' process, our developmental findings for the presumed 'phonetic' process were not in the expected direction. These findings lead us to further pursue our experiments. We have chosen to pursue our general approach to the issues in question but to run another series of experiments in which the tasks are both freer of assumptions which are difficult to justify and in which they tap more clearly presumed 'auditory' versus 'linguistic' processes.

Figure 28a: Study 2. Amplitude envelopes of two stops and two fricatives in speech

Note. All four abscissae and all four ordinates are partitioned similarly.

STOPS



FRICATIVES

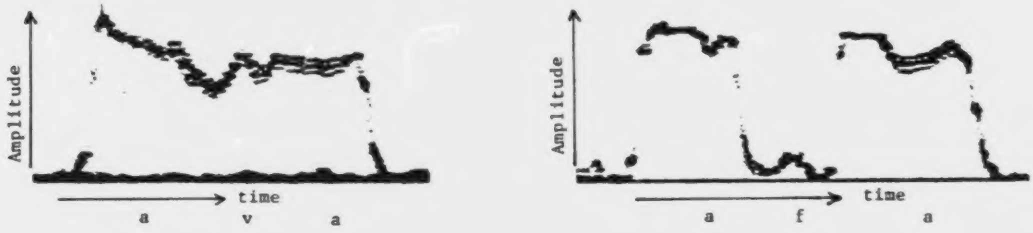
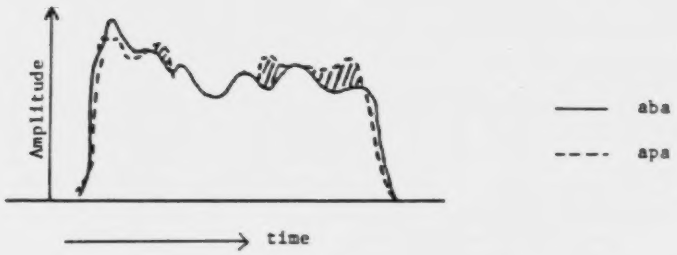
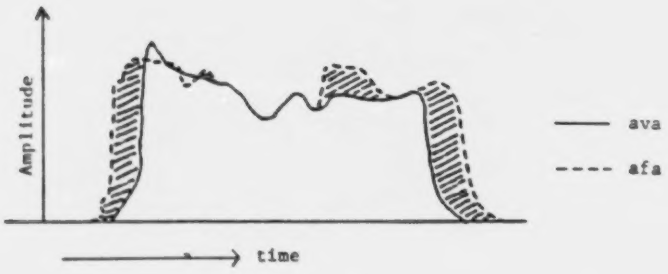


Figure 28b: Study 2. Difference in the amplitude envelopes of vocalic portions of two stops and two fricatives in speech

STOPS



FRICATIVES



CHAPTER 4

Study 3: Auditory Versus Phonetic Processes in the Categorization of Consonants

and

Study 4: Phonetic Processes in the Categorization of Consonants, Comparison Across Classes of Responses

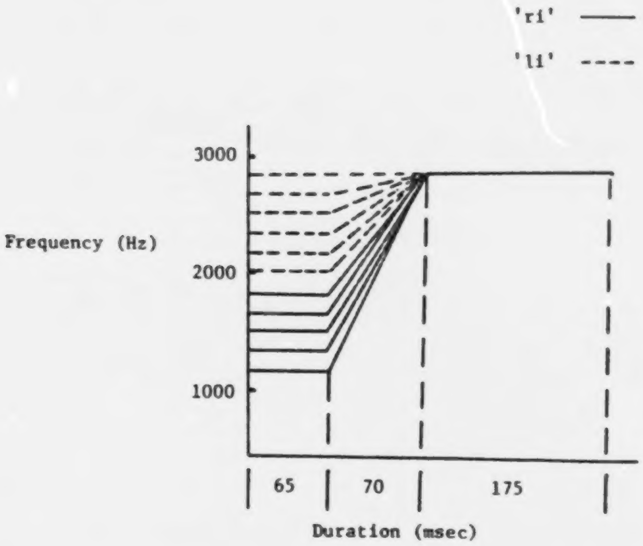
STUDY 3 & STUDY 4: INTRODUCTION

In order to investigate the existence of auditory versus phonetic processes in the perception of speech sounds, this series of studies made use of the following findings. As mentioned in Chapter 1, synthesized consonants varying in vowel context and position do not seem to possess physical characteristics which are invariant across these different contexts. Thus, in a series such as synthetic tokens of ri or ru ir, there does not seem to exist an invariant physical attribute for 'r' across the different contexts. Perception of the invariant nature of 'r' across these contexts would require, according to Liberman et al. (1967), the operation of a specialized linguistic processor. On the other hand, many experiments dealing with the auditory/phonetic processing distinction through the classification of speech sounds have made use of synthesized consonants presented either in a CV or VC context and varying only in the physical parameters sufficient to produce the percept of one given CV or VC. Thus, in contrast to the above series, a series such as ri ri ri ri such as shown in Figure 29 and which represents different tokens of ri and li formed by varying only the starting frequency of the initial portion of the third formant, is an example of such a series of synthetic consonants. It will be observed that the physical parameters distinguishing variants of a given perceptual CV consist of a relatively easy to describe invariant, namely, as shown in Figure 29, if F3 starts below 2000 Hz, it can be called ri. Based on the above, we will hypothesize that two different modes of categorization exist, one phonetic, and which is called into play in the categorization of the ri or ru ir series, and one auditory, and which is called into play in the categorization of the ri ri ri ri series.

Our approach will be again, briefly for now, as follows. We expect different developmental trends to characterize what we have assumed to be two different processes of categorization. Furthermore, we expect specific patterns of development to characterize what we have labelled acoustic and phonetic processes of categorization, and we expect these patterns to differ somewhat between males and females. Finally, we expect degree of second language knowledge to affect differentially acoustic versus phonetic processes of categorization.

The literature with respect to the hypotheses we have entertained can be summarized as follows. There are three types of studies. The first type of studies deals with a phenomenon in adults which has been labelled "categorical perception" and which initially claimed to be one proof for the existence of a linguistic mode in the categorization of speech sounds. It will be argued below that, after much research, the issue cannot be said to have been definitely resolved. The paradigm used for studies on "categorical perception" is the following. When adults are presented with various synthetic tokens of two syllables differing linguistically in one phonetic segment or not at all, and physically along one physical continuum, such as five different physical tokens of the ri and the six different physical tokens of the li from Figure 29, identification functions are clearcut, and discrimination functions parallel the identification function. More specifically, let us assume, as can be seen in Figure 30, that we have eight synthetic speech stimuli whose distinguishing physical cue is spaced at equal physical intervals along a continuum. If the stimuli

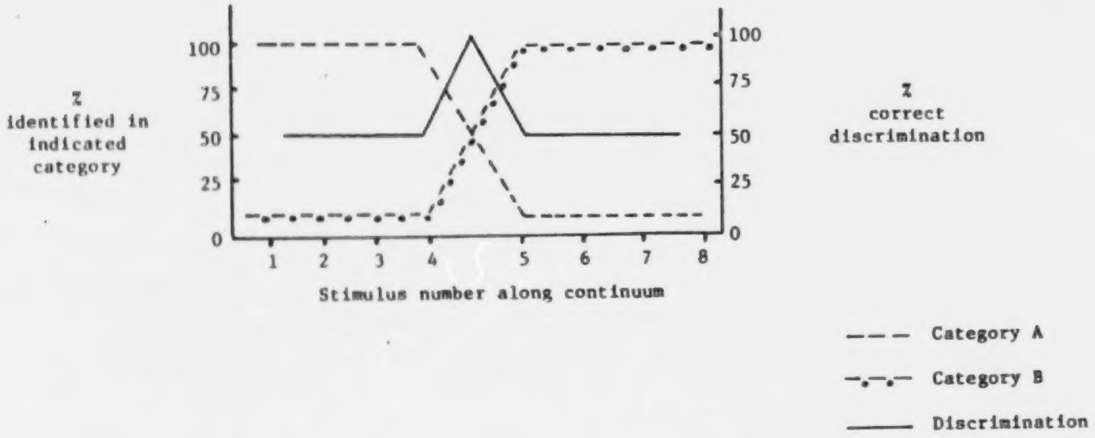
Figure 29: **Frequency and duration values for tokens of ri and li 3rd formants only (McGovern & Strange, 1977) (Used by permission)**



are presented for *identification*, stimuli 1 to 4 will be identified as tokens of category A 100% of the time and as tokens of category B 0% of the time, and the reverse will be true for stimuli 5 to 8. Also, if pairings of the stimuli are presented for *discrimination* (for example, stimulus 1 versus stimulus 2, or stimulus 4 versus stimulus 5) with the physical steps between the stimuli of a pair being kept constant, stimuli usually *identified* as belonging to the same phonetic category (e.g. [p] [a] or [b] [a]) will be discriminated essentially at chance (50% correct discrimination for stimulus 1 from stimulus 2) and those identified as belonging to different categories will be perfectly discriminated (100% correct discrimination for stimulus 4 from stimulus 5). This mode of responding to stimuli drawn from a physical continuum has been called categorical perception, and involves three factors: identification probabilities which change abruptly somewhere along the continuum, with near perfect or near zero uniform performance on either side of the abrupt change; discrimination functions which show a peak at the category boundary (this is usually the point of maximum slope of the identification function); discrimination functions which are at chance or near chance levels within each identification category (Studdert-Kennedy, Liberman, Harris & Cooper, 1970). The general inference that has been made is that performance within the above paradigm is a reflection of the operation of the speech-special linguistic process postulated by Liberman et al. (1967) to operate in the processing of speech sounds.

The phenomenon of categorical perception has been studied mainly for stop consonants, and mainly in initial position of consonant-vowel syllables. We shall also focus our discussion in the same direction, and touch on other linguistic units and contexts only as they will be seen to be relevant to our discussion of the categorical perception of stop consonants. The phenomenon is replicable (for example, Liberman, Harris, Kinney & Lane, 1961; Pisoni & Lazarus, 1974). There are, to-day, mainly two types of explanations for the phenomenon: those that see in it the operation of a phonetic mode albeit in addition to the operation of the auditory mode (for example, Pisoni, 1978; Pisoni & Lazarus, 1974). This modified position is arrived at mainly because of the finding that the categorical perception function may not be as perfect as described graphically in Figure 30. According to Pisoni (1978, p. 198) "categorical perception is also due, in part, to encoding processes in short-term memory that result from the particular type of discrimination task used in these experiments ... The ABX procedure has been used in almost all

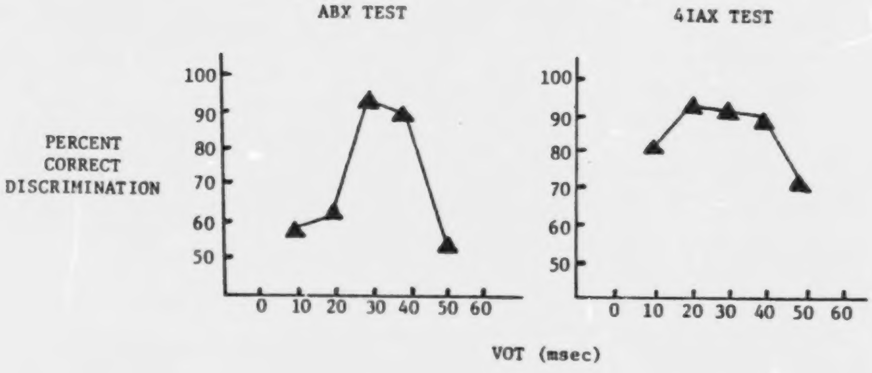
Figure 30: **Discrimination and identification of eight synthetic consonant-vowel syllables distributed at equal intervals along a physical continuum (Studdert-Kennedy, Liberman, Harris & Cooper, 1970) (Used by permission)**



of the speech-perception experiments demonstrating categorical perception. In this task subjects are presented with three sounds successively, ABA and ABB. A and B are always acoustically different, and the subjects have to indicate whether the third sound is identical to the first or second sound. This is basically a recognition-memory paradigm. In order to solve the discrimination task, the subjects are forced to encode the individual stimuli in temporal succession and then base their decision on the encoded representations that have been maintained in short-term memory rather than to respond to the magnitudes of difference between stimuli within an ABX triad. In a number of experiments, Pisoni .. has shown that differences between categorical and continuous modes of perception are crucially dependent on the memory requirements of the particular discrimination procedure and the level of encoding required to solve the task ...". In one study, Pisoni and Lazarus (1974) presented subjects with two forms of the discrimination task. The standard ABX form, as mentioned above, requires encoding of stimuli, thus biasing toward a phonetic mode of processing. The 4IAX form, permits the subject to base his decision on a pair-wise comparison and thus respond to the magnitude of differences between pairs of stimuli. The stimuli differed in VOT, varying from zero VOT through +60 msec VOT in 10-msec intervals. Stimuli were arranged in a sequential order from /ba/ through /pa/ based on VOT. In the discrimination test, the stimuli were arranged in triads for ABX presentation, where A and B were different stimuli and X was either A or B. In the other discrimination test, the stimuli were arranged in two pairs for 4IAX presentation, where one pair, A - A, was always the same, and the other pair, A - X always different. The discrimination tests used differences that were two steps apart on the VOT continuum. There was a two-second interval between stimuli. In the ABX discrimination test, subjects reported whether the third stimulus was most like the first or most like the second. In the 4IAX discrimination test, subjects reported which pairs of stimuli were the same, the first pair or the second pair. This procedural contrast was designed to facilitate a more nearly categorical mode of discrimination in the ABX test and more nearly continuous mode of discrimination in the 4IAX test. As can be seen from Figure 31, this is indeed what is obtained. The other category of researchers see in categorical perception a reflection of psychophysical processes albeit in addition possibly to the operation of a phonetic mode (for example, Pastore, 1981).

The second and third type of studies are developmental studies with speech stimuli, but they cannot be said, with a strong degree of certainty, to be tapping the operation of the specialized linguistic processor according to the criteria of Liberman et al. (1967). The second type of studies

Figure 31: **Average two-step discrimination functions obtained with the ABX and the 4IAX tests (enlarged) (Pisoni & Lazarus, 1974) (Used by permission)**



looks at categorization of stimuli whose varying physical characteristics may be said to contain a relatively easy to classify invariant, such as the tokens of ri and li in Figure 29. The studies of Kuhl (1980), Tallal, Stark, Kallman and Mellits (1980), Wolf (1973) are of that variety. For example, Wolf (1973) looked at categorization of ba versus pa tokens or of da versus ta tokens. These are easily transcribable into a classification analogous to that shown in Figure 29. Kuhl (1980) tested for example categorization of fricatives in CV and VC contexts. She varied the token, the vowel and the talker. Fricatives are well known to have clear invariant characteristics. Figures 32 and 33 show spectrograms of two types of fricatives in different contexts, spoken within a sentence. Tallal et al. (1980) looked at categorization of b versus d in synthetic tokens of bae bε bi versus dae de di. As can be seen from the spectrograms of their stimuli in Figure 34, their phonemes are easily classifiable acoustically as three-formant (d) versus not three-formant (b) stimuli; or also as broad formants (b) versus narrow formants (d) stimuli. The third type of studies have used paradigms possibly inappropriately presumed to provide indices of the operation of the specialized linguistic processor. The studies of Morse (1972), Eimas, Siqueland, Jusczyk and Vigorito (1971), Trehub (1973) are of this variety. All of these studies have used variations of one aspect of the categorical perception paradigm. This has been an adaptation of the discrimination task with the intent to replicate the peaks and troughs of the discrimination function described before to index phonetic processing. The arguments about the extent to which this discrimination function can be safely considered to be an index of phonetic processing have been shown, in the section on categorical perception, to be the subject of much debate. There is one additional small piece of evidence which adds to the caution we must have in our interpretation of that discrimination function. It is the following. Patients with damage of the left hemisphere may show a normal discrimination function, and yet lack a normal identification function (Blumstein, 1978).

Thus, in a further attempt to find an answer to the question of whether there exist two separate processes in the perception of speech, one for simple acoustic categorization, another for purely linguistic categorization, we used two types of stimuli, those whose varying physical characteristics may be said to contain a relatively easy to classify invariant of the type described in Figure 29, and those whose varying physical characteristics may be said not to contain a relatively easy to classify invariant of the type described in Figure 3, for example. Subjects heard a set of stimuli which involved repetition of the category to be tested and at a certain point the set changed to one which involved repetition of another category. For example, ri ri ri, for 'r' category, with about four seconds between stimuli, changed to li li li li li for 'l' category, or ri or for 'r' category changed to li εl lo li ol lε for 'l' category.

The subject's task was to respond when the *change* in category occurred. The first two stimuli cued the subject as to which category was first being repeated and subjects were pre-trained to ignore vowels.

The paradigm fulfilled three objectives. It attempted to establish the existence of two forms of categorization of speech sounds, one called acoustic categorization of speech sounds, another called linguistic categorization of speech sounds, using the same paradigm. This eliminated the problem of task differences as possible confounds for the results obtained with the two types of stimuli, except that perceiving the consonantal invariant in the series ri or li ɛl, etc., required ignoring the variation in the vowel and ignoring the variation in consonant position, whereas perceiving the consonantal invariant in the series ri ri ri li, etc., did not require the above. Thus, the task with the series ri or li ɛl, etc., was more difficult than that with the series ri ri ri li, etc., and as such presented a problem in the interpretation of the data. The paradigm also permitted subjects to respond merely to magnitudes of difference between stimuli rather than base their decision on the encoded representations that have been maintained in short-term memory. Simplifying the task thus permitted each categorization to be performed at a simple level. Finally, the paradigm was applicable across a wide range of ages from the very young all the way to mature subjects, resembling in many respects the habituation-dishabituation paradigm traditionally used with infants (Eilers, 1980). This eliminated the problem of task differences as possible confounds for the developmental results obtained.

Figure 32: A spectrograms of "la*sh*, fa*c*e, vase" (British accent) (Ladefoged, 1975) (Used by permission)

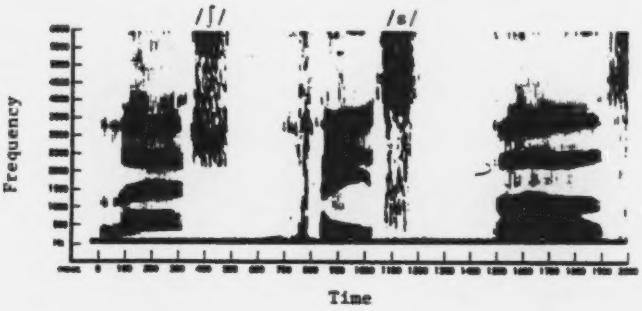


Figure 33: A spectrogram of "*Sh*e came back and *s*tarted again" (British accent) (Ladefoged, 1975) (Used by permission)

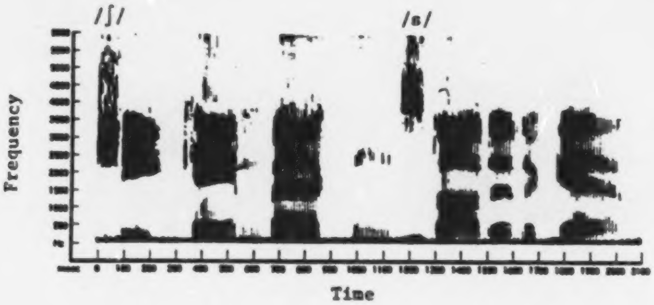
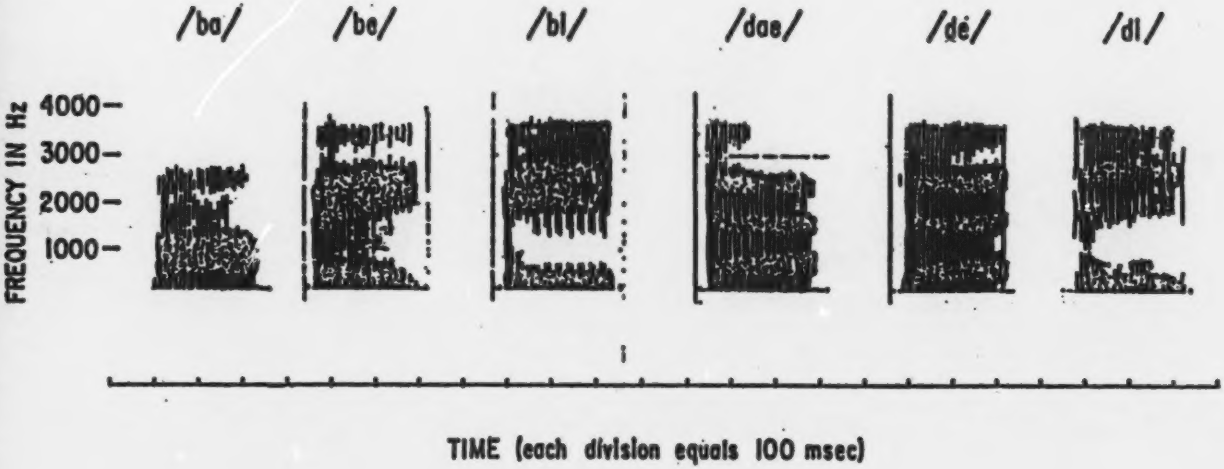


Figure 34: Spectrograms of syllables used as stimuli in Tallal et al. (1980) study (Tallal, Stark, Kallman & Mellits, 1980) (Used by permission)



As was described in the General Introduction, speech sounds can be perceptually classified in terms of their features, in terms of the phonetic segments they belong to, and in terms of the phonemes they belong to, and the classification is hierarchical. In the two studies described below, we manipulated phonemes. Our interest, as already mentioned, was in the auditory/phonetic or auditory/linguistic processing distinction. As mentioned previously, there were two tasks, one with a series such as ri ri ri ri and another with a series such as ri or ru ir. In both tasks, perception of the invariance in the consonant is called for. The first task, however, presumably does not necessitate any mechanism specific to speech, whereas the second task does. Our tokens were CV's and VC's produced naturally in different vocalic contexts as part of real words. The consonants were p, b, t, d, k, g. In the French language, which was the language of the experiment, these are known to contain phonetic variations, e.g., dʰɛ vs. id. Therefore both tasks involved phonemic categorization, but only one task was presumed to require any mechanism specific to speech. As other studies in the auditory/linguistic area, our focus here is on the auditory/linguistic distinction, and we choose to ignore the significance of the linguistic levels at which the task is performed, be it featural, segmental or phonemic.

We postulated that two different mechanisms may be operative for the processing of speech sounds, that perceiving the invariant consonant in the sequence ri ri ri ri necessitates one type of mechanism and perceiving the invariant consonant in the sequence ri or ru ir necessitates another type of mechanism. Different patterns of development in the performance of the two tasks would be an indication of the existence of two different processes.

We furthermore postulated that perceiving the invariant consonant in the sequence ri ri ri ri does not require a mechanism specific to speech, since similar categorizations of nonspeech sounds have been achieved (Lane, 1965). If there is a mechanism specific to speech it should operate in the perception of the invariance in the sequence ri or ru ir, as such categorization of nonspeech sounds has not yet been documented. Again, then, if acoustic modes of processing are well developed by age 6 - 8, as postulated before, but if phonetic modes of processing do not reach their full capacity until age 10 or more, the developmental trends should be as follows. Perceiving the invariant consonant in a sequence such as ri ri ri ri should be very good at ages 6 - 8, 10 - 12, and 16 - 19; perceiving the invariant in a sequence such as ri or ru ir should be poor at age 6 - 8 and then should become very good at ages 10 - 12 and 16 - 19. Next, we hypothesized that there should be no difference between males and females on developmental trends of indices of acoustic modes of processing but that males should lag somewhat behind females on developmental trends of indices of phonetic modes of processing. More specifically, for males, the improvement in performance described above for the sequence ri or ru ir should occur somewhat later than age 10 - 12, that is, somewhere between ages 10 - 12 and 16 - 19. Finally, we expected that knowledge of a second phonetic system (that is, a second language) should influence differentially phonetic versus auditory modes of processing. This assumption was derived from the thinking that elements belonging to a given system interact differentially with elements belonging to the same system, as compared to their effects on elements belonging to other systems. For example, findings of interference and facilitation from knowledge of another language in bilinguals when dealing with one of their languages (Weinreich, 1963), appear to us to be an index of such a differential effect. Since the task that was presumed to involve a linguistic process was a phoneme categorization task, we decided to assess the degree of bilingualism of our subjects by focusing more precisely on their degree of bilingualism with respect to factors presumed in the literature to measure more directly phoneme categorization. There are two classes of theories that may account for phoneme or segment identification. They are a) productive theories, and these deal mainly with phonetic segments, and b) post-lexical theories, and these deal mainly with phonetic segments and phonemes. Although this thesis is mainly a test of the first type of theory, we decided to use both theories in our attempts to elucidate the effects of bilingualism. For the first type of theory, Liberman et al. (1967) postulate that such perception is mediated by the motor commands which guide the production of these sounds and which are postulated to be of an invariant nature. For the second type of theory, such identification occurs after the word has been accessed (Foss, Harwood & Blank, 1980; Klatt, 1980). It is therefore hypothesized that two types of indices of bilingualism could exert the expected influence, productive abilities, and lexical access abilities in the second language. Each subject, then, was given a global score on his degree of bilingualism, on the basis of these two indices.

Because productive theories have had a long history, because they are the main focus of this thesis and because there is some physiological evidence for their validity (study carried out by Taylor, Milner & Darwin and cited in Ettlinger, Teuber & Milner, 1975) we arbitrarily decided to assign slightly more weight to them when evaluating our subjects' degree of bilingualism.

The aim of Study 3 was to test, using a single response mode, all of the hypotheses mentioned above with respect to Acoustic Categorization and Linguistic Categorization, whereas the aim of Study 4 was to confirm more specifically, utilizing various response modes, the hypotheses put forward about Age by Sex effects with regard to Linguistic Categorization.

STUDY 3: METHOD

In this study sets of eight natural syllables which each contained a change of one consonantal phoneme were presented auditorily to males and females aged 7, 11 and 17 who each contained the whole range of degree of second language knowledge from the completely unilingual to the completely bilingual. The syllables contained one consonant and one vowel. The sets of eight natural syllables presented the consonantal phonemes either as a series of phonetic variants of a given CV or VC or as a series of phonetic variants of C's in a context of alternating position within the syllable and changing vowel. The former task was called Acoustic categorization, the latter Linguistic categorization. Three sets of consonantal phonemic constrasts were employed: p/b, t/d and k/g. Subjects had to detect the appearance of change in consonantal phoneme within a set by pressing a key at the point of change. It was hypothesized that there would be a significant difference in the pattern of development for performance on the Acoustic categorization task compared to the Linguistic categorization task. It was furthermore hypothesized that, for both males and females, Acoustic categorization should be performed close to perfectly for all three age groups. For Linguistic categorization, it was hypothesized that, for females performance should be close to chance levels at age 7, and close to perfect levels at ages 11 and 17, whereas for males performance should be close to chance levels at age 7 and 11, and close to perfect levels at age 17. Finally, pooling across ages and sexes, it was expected that the linear regression between degree of bilingualism and performance on the three phonemic contrasts employed should be significantly different for the Acoustic categorization task compared to the Linguistic categorization task.

Subjects

Subjects were francophones varying in their degree of French/English bilingualism from the completely unilingual to the completely bilingual. They came from two public schools in middle- to upper-middle class areas of Montreal. As will be more fully described in the Procedure section, all subjects had had previous experience with the experimental setting and stimuli of Study 3, thus rendering them familiar with many aspects of the experimental situation of Study 3. All subjects had a normal auditory history. They belonged to three age groups, age 7, age 11, and age 17.

Subjects were selected for degree of bilingualism by a detailed questionnaire on knowledge, acquisition histories and use of the subject's language or languages, which was completed by parents who consented to their son's or daughter's participation in the study. The questionnaire was a French age-adjusted and refined adaptation of the one used by Vaid and Lambert (1979) (for questionnaire, see Appendix 13a). The questionnaire was selected as our only measuring instrument for several reasons. Ideally, to get measures of degree of bilingualism, one should directly measure and assess the skills one is interested in. However, this method is too time consuming. It involves assessing the specific skills in all possible contexts, going from the very formal at one end to the very informal at the other (Macnamara, 1967). Macnamara (1967) utilized step-wise regression to find a number of "indirect" measures which could be more efficiently used as optimal predictors for a number of direct linguistic skills. With respect to the two skills of interest to us, namely productive abilities in the second language and lexical access abilities in the second language, Macnamara found that indirect self-rating measures of second-language speaking skills were the best predictors, and measures of the extent of second-language use in the home environment, the next best predictors of productive abilities in the second language at the phonetic level, i.e., phonetic errors in retelling a story. Indirect self-rating measures of listening skills were the best predictors and measures of the extent of second language use in the home environment, were the next best predictors of lexical access abilities in the second language, i.e., lexical interference in a written essay. This indicated that the three factors which were important predictors of the skills of interest to us were production of the second language, current usage of the second language, and comprehension of the second language. Since all three factors were well assessed in the questionnaire (see Appendix 13b for questions referring to the three factors), it was felt to be an adequate measuring instrument. We added, on an intuitive basis, a fourth factor, age of acquisition of second language, as a weak and equal predictor of the two skills. This factor as well is assessed in the questionnaire (see Appendix 13b for questions referring to this factor). On the basis of responses to the above four factors within the questionnaire, a global score of degree of bilingualism was assigned to each subject. Scoring was on a continuous scale from 1.0, unilingual, to 10.0, strongly bilingual (for complete details on mode of scoring see Appendices 13b and 13c).

Subjects were selected for normal auditory history by a negative school record in terms of problems of audition, and a negative parent report in terms of problems of audition (see Appendix 14 for questions asked).

The number of subjects by age and sex were:

six male and six female children age 7 (female mean = six years, 11 months, male mean = seven years, two months);
six male and six female children age 11 (female mean = 10 years, 11 months, male mean = 11 years, three months);
six male and six female adults age 17 (female mean = 17 years, five months, male mean = 17 years, two months).

Within each Age and Sex group, the whole range of degree of bilingualism was represented, from complete unilingualism to complete bilingualism. The mean degree of bilingualism scores for each Age by Sex subgroup was:

Males, Age 7:	3.598
Females, Age 7:	5.903
Males, Age 11:	6.182
Females, Age 11:	5.396
Males, Age 17:	5.060
Females, Age 17:	5.305

Subjects came from the following institutions in Montreal:

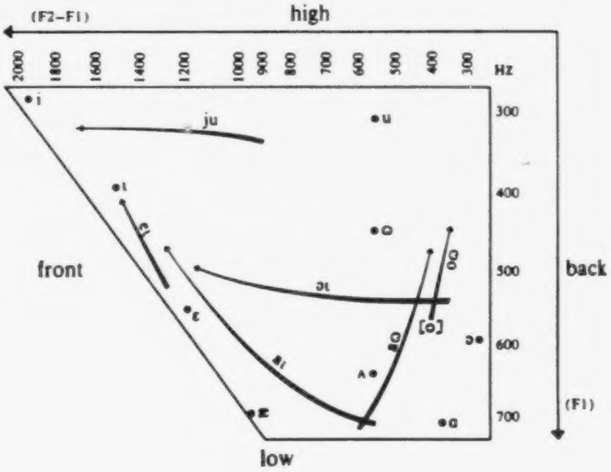
1. At ages 7 and 11, they came from École Notre-Dame-de-Grâce (a public school),
2. At age 17, they came from École Secondaire St-Luc (a public school). Age 17 subjects, thereafter called also the 'adult' subjects, were paid approximately $4.00 per session.

Stimuli

The consonant stimuli selected were the stop consonants p, b, t, d, k, g. These consonants were chosen because they are the ones found by Liberman et al. (1967) not to contain an invariant when in different positions and different vocalic contexts. The French phonetic forms of these consonants were used. The vowel stimuli selected were the French [ε], [i], and [o]. These particular vowels were chosen because, though not maximally so, they are well apart in the vowel space. The advantage of such wide spacing, as can be seen in Figure 1 especially, is that spectrographically the effect seems to be to render given consonants much more distinct one from the other (i.e. much less invariant) as the vocalic context is varied. Indeed, if one examines the di dε do spectrograms in Figure 1, one can see that for di, the spectrogram is characterized by two very widely spaced formants, the first barely rising from its inception point, the second on the other hand rising *substantially so*. For dε, however, the two formants are now nearly twice as close one to the other, though still quite apart; the first formant now exhibits a much steeper rise whereas the second formant is completely *horizontal* (i.e. no rise at all). Finally, for do, the formants are very nearly touching one another, the first formant again exhibits not much of a rise and for the second formant the trend is reversed, i.e. it tends fo *fall*, and quite substantially so, from a rather high inception point. (Such drastic changes would not have been noted had we chosen, for example, stimuli equivalent to dɔ, do, and du from Figure 1 instead.)

The consonants and vowels selected also fulfilled another condition. They are phonemic in both Montreal English (Nicole Domingue, personal communication), and Montreal French (Benoit Jacques, personal communication). Figure 35 shows the spacing of vowels. Unfortunately the Figure represents vowels of *American English*, but for our purposes it is equally applicable to the vowels of Montreal French and English as the [ε], [i], and [o] which we used actually exist in all three linguistic systems.)

Figure 35: **A combined acoustic and auditory representation of some of the vowels of American English (Ladefoged, 1975) (Used by permission)**



French words were chosen in such a way as to include within them one of the above consonants, combined with one of the above vowels, either in the form of CV or VC. For example, for the consonant p and the vowel ε, the underlined part of the word '*paix*' would represent the form CV and the underlined part of the word '*hep*tagone' would represent the form VC. To allow for all possible combinations, therefore, 36 words were generated, including the six consonants p, b, t, d, k, g, the three vowels ε, i, o, and the two orders CV, VC. See Appendix 15 for list of words used. A list of 180 words, hereafter called the Speaker's Reading List, was made up which consisted of a random arrangement of five tokens of each of the 36 French words mentioned above and listed in Appendix 15. This list is given in Appendix 16.

The speakers were one male and one female francophone, both students in their twenties. Each speaker was recorded reading the Speaker's Reading List from a sound-proof booth. The speaker spoke into a microphone (Philips EV 7011/22) which fed into a tape-recorder located in an adjoining room (PIONEER, model RT-1020H). Taping was done on 1.5 mil., polyester low noise tapes. Stimuli were recorded at 7½ inches per second.

Preparation of tapes: task for Acoustic Categorization of speech sounds. As mentioned in the Introduction, the paradigm consisted of a repeating series of the same C_1V_1 or V_1C_1, and at a certain randomly chosen point this was replaced by another repeating series of C_2V_1 or V_1C_2. Each such grouping of a repeating series of C_1V_1 or V_1C_1 followed by another repeating series of C_2V_1 or V_1C_2 is thereafter called a set. Arbitrarily, we chose to have eight elements within each set and to locate the position of change at the third, fourth, fifth, sixth or seventh element. Ten different sets were created for the Acoustic Categorization Task. The ten sets of contrasts that had been selected were k/g, b/p, g/k, t/d, g/k, t/d, p/b, d/t, p/b, and b/p. Half of the sets were randomly chosen to be of the voiced to voiceless change variety, the other half to be of the voiceless to voiced change variety. The positions of change were randomly assigned to the third, fourth, fifth, sixth, or seventh element, so that two sets contained the change at position 3, two at position 4, two at position 5, two at position 6, and two at position 7. One-half of the eight-element sets started with a CV, the other half with a VC (see Appendix 17). The monosyllables were extracted from the recording made by the male speaker. Within each repeating series, different tokens of a given CV or VC were used for adjacent members, so that they would be identical phonemically but not necessarily phonetically or acoustically. The tokens were chosen from among the five exemplars recorded (see Appendix 16). To control for the effect of order of presentation, two orders were recorded. The forward order had sets one to ten, as described above, and the backward order had sets ten to one (see Appendix 17). About five seconds were allowed between elements within a set, and 12 seconds between sets. The intensity of output was preset by having the assistant and the experimenter hear the tapes and agree, for each, on the most comfortable level.

Preparation of tapes: task for Linguistic Categorization of speech sounds. In this case, a repeating series of the same C_1 was employed, but in changing vocalic contexts and in changing locations within the syllable (i.e., C_1V_1 V_2C_1 C_1V_3). Again, at a certain randomly chosen point, this C_1 was replaced by another repeating series of the same C_2, also in changing vocalic contexts and in changing locations within the syllable (i.e., V_2C_2 C_2V_1 V_3C_2 C_2V_4 V_5C_2). As in the Acoustic Categorization task, we arbitrarily chose to have eight elements within each set, to locate the position of change at the third, fourth, fifth, sixth, or seventh element, and to make up ten different sets. The ten sets of contrasts that had been selected for the Acoustic Categorization task were also used here. These were k/g, b/p, g/k, t/d, g/k, t/d, p/b, d/t, p/b, and b/p. Half of the sets were randomly chosen to be of the voiced to voiceless change variety, the other half to be of the voiceless to voiced change variety. However, these ten sets were presented in a different randomly selected order (see Appendix 18). The three vowels ɛ, i, o, were about equally represented within each set of eight elements, and vowels always changed from one element to the next. Within each eight-element set, about half the elements were of the form CV, the other half of the form VC. At the position of change within each eight-element set, the change *always* involved a change from VC to CV or vice versa. One-half of the eight-element sets started with a CV, the other half with a VC. As for the Acoustic Categorization task, the positions of change were randomly assigned to the third, fourth, fifth, sixth, or seventh element, so that two sets contained the change at position 3, two at position 4, two at position 5, two at position 6, and two at position 7. As for the Acoustic Categorization task, the monosyllables were extracted from the recording made of the male speaker, a forward and backward order were recorded to control for the effect of order of presentation, and there was about five seconds between elements within a set and twelve seconds between sets. Again, the intensity of output was preset by having the assistant and the experimenter hear the tapes and agree, for each, on the most comfortable level.

For both the Acoustic Categorization task and the Linguistic Categorization task, in order to objectively and with no subject interference ascertain that a response was made to the change stimulus we used reaction time to get the dependent variable. To obtain this measure, a Diapilot (UHER F422, Serial No. 247421) was used. At the onset of the first element of each set, a pulse was recorded on an unused and nontransmitting channel of the tape. This turned on a stop-clock (Lafayette Instruments, Lafayette Indiana, Model No. 20225ADW, Serial No. 901015) that was turned off by the subject's pushing a green response button.

Procedure

The experiment was conducted in a quiet room within the school for ages 7 and 11, or the university for age 17. A female francophone assistant was the only person present with the subject during the actual testing. She was blind to the actual purpose of the study, having been told only that the experiment was on language acquisition. (For a visual display of the apparatus and setting, see Appendix 19). The two rooms used for running the experiment were the Experimental Room, in which the subject had to respond appropriately to the tasks, and the Data Recording Room, which was completely separated from the Experimental Room. The Experimental Room contained a table and a chair for the subject, and another chair, back to back with the subject's chair, for the blind assistant. On the table was a loudspeaker (from taperecorder SONY, TC-200, Serial No. 145012) facing the subject's chair and located some 8" from the table edge next to the subject. In front of the loudspeaker, about 2" from the table edge, was a custom built response key with two buttons, one red, one green. The buttons were at right angles to the subject, and the red button was always nearest to the subject.

The Data Recording Room contained two tables and a chair. On one table was the tape recorder (a SONY, TC-200, Serial No. 145012) and the Diapilot. On another was the stop-clock in a box lined with soundproof foam and a custom-built power supply. There was also a small bench on which there was a loudspeaker (from taperecorder SONY TC-200, Serial No. 209220). The loudspeakers in the Experimental Room and in the Data Recording Room were connected to the taperecorder. The experimenter in the Data Recording Room controlled what stimuli were being given to the subjects and heard the stimuli at the same time as they were being heard by the subject in the Experimental Room. The tape, as it was being played, passed through the Diapilot (see Appendix 19), which, at every occurrence of a pulse, activated a latching relay which started the clock. The subject's pressing of the green response key unlatched the relay and stopped the clock. The experimenter also had a response key, which was used on trials where the subject did not press the response key during the passage of the eight elements of a given set. The experimenter stopped the clock about ten seconds after the passage of the last element within a given set.

All subjects had previously been seen four times. These represented an earlier, less refined and unanalyzed, attempt at the actual Study 3. It involved the same setting and stimuli. Additionally tests of the blind assistant's competence and of the subject's comprehension of the instructions were conducted. However, the instructions for the Acoustic versus Linguistic Categorization task were less refined than in the present Study 3. For the present experiment, each subject was seen twice, once for the Acoustic Categorization task, the other for the Linguistic Categorization task. For the *Acoustic Categorization* task, the subjects were instructed by the Experimenter that they would hear series of French nonsense words of the following format:

pa pa pa ba ba ba ba ba

They were told that they were to ignore the vocalic portion of each word (as demonstrated by pronunciation aloud) and attend only to the consonantal portion of each word (also as demonstrated by pronunciation aloud). They were instructed that the first two words shared the same consonantal phoneme, and that at a certain point after the second word this consonantal phoneme would change. The phoneme was defined for the subject according to the strict phonemic approach. The subject's task was to find when this change occurred by pressing the response key (for complete instructions, see Appendix 20). During the actual testing, the subject sat facing the table, while the blind assistant sat with her back to the subject. The assistant would tell subjects at the end of each set to put their finger back on the red button because a new set would be starting (if the subject had not noticed a change and still had the finger on the red button, the assistant told the subject that the change had occurred and that now a new set was starting). During this time the experimenter was in the Data Recording Room recording the subject's reaction time as well as the correctness of the response and resetting the stop clock. At the end of five sets, the subject was given a break of a few minutes, filled by the assistant and experimenter with talk of school and home activities, of summer holidays, etc., and then, after the Experimenter's praising the subject for performance on the first five sets, the other five sets were presented. The whole procedure for the Acoustic Categorization task took about fifteen minutes.

For the *Linguistic Categorization* task, subjects were instructed by the Experimenter that they would hear a series of French nonsense words of the following format:

pɛ ip po pɛ op bi ɛb bo

They were told to ignore the vocalic portion of each word (as demonstrated by pronunciation aloud) and attend only to the consonantal portion of each word (also as demonstrated by pronunciation aloud). They were instructed that the first two words shared the same consonantal phoneme, and that at a certain point after the second word this consonantal phoneme would change. The phoneme was defined for the subject according to the strict phonemic approach. The subject's task was to find when this change occurred by pressing the response key (for complete instructions, see Appendix 21). The actual testing was carried out in the same manner as for the Acoustic Categorization task.

The order of the tasks was counterbalanced within each age and sex subgroup and the tasks were given in different sessions. The interval between sessions was on the average three to four days.

STUDY 3: DESIGN

There were three age groups (age 7, 11, 17) and two sexes (male, female), with six subjects nested within each of these age-sex cells. On each of the two sessions' tasks there were four trials for the p/b constrast, three for the g/k contrast, and three for the d/t contrast. Each trial was scored as correct or incorrect. The dependent variable was percent correct for change detected in each type of phoneme contrast (p/b, t/d, or k/g) within each type of task (Acoustic Categorization, Linguistic Categorization) and was computed as

$$\frac{\text{Number of correct trials with given phoneme exemplar}}{\text{Number of existing trials with given phoneme exemplar}} \times 100$$

A correct response was defined as a button press occurring within the time limit defined by the beginning of the change stimulus to the beginning of the stimulus occurring immediately after the change stimulus. See Appendix 22 for the complete design.

The first type of analysis was a four-way ANOVA with repeated measures on two factors. This consisted of three levels of age (A) (Ages 7, 11, 17), two levels of sex (X), and six subjects nested within each age-sex combination. The repeated factors were: Type of Task (T), which consisted of two levels, Acoustic Categorization and Linguistic Categorization; and Type of Phonemic Contrast (C), which consisted of three levels, p/b, t/d, and k/g. The factors not analyzed for were the order of Type of Task (counterbalanced), and the direction of list presented, forward (trials 1 to 10) or backward (trials 10 to 1) (quasi randomized since it could not be counterbalanced). The other factors not analyzed for were randomly assigned. Within both tasks, these included the type of phonemic contrast (p/b, g/k, d/t) within a set, the type of sequence change at the point of change (voiced to voiceless, voiceless to voiced) within a set, and the position of change (3, 4, 5, 6, or 7) within a set. Other factors not analyzed for and randomly assigned within the Acoustic Categorization task were the type of vowel within each phonemic contrast (ε, i, o) within a set, and the type of syllable (VC or CV) within a set. Other factors not analyzed for and randomly assigned within the Linguistic Categorization task were the type of first vowel within each phonemic contrast (ε, i, o) within a set, the type of syllable for the first stimulus of a set (VC or CV), and the type of vowel (ε, i,o) within each element of each set.

The second type of analysis was linear regression (pooled across ages and sexes) between degree of bilingualism and task for each contrast.

STUDY 3: RESULTS

Since the hypothetically correct reaction times might contain some error due to some *inherent* variability of the measuring instrument (that is, the experimenter's own variable reaction time, and/or the tape recorder's own speed variation), and since the hypothetically correct reaction times might contain some error due to *systematic* variability of the measuring instrument (that is, stretching of the tape over time, and/or more systematic alterations in tape recorder speed due to usage), these factors were checked for as follows. The theoretically correct measurements were those which were taken just prior to running the experiment. To verify the existence of *inherent* variability of the measuring instrument, all theoretically correct measurements were compared against an identical set of measurements taken immediately after the theoretically correct measurements. To verify the existence of *systematic* variability of the measuring instrument, all measurements were replicated at the end of the experiment and compared to the theoretically correct measurements. Since the experiment extended over a period of a month, to ensure accuracy, theoretically correct measurements were taken at every two week interval. Thus, we have two series of measurements of error. The first series corresponded to the running of the seven and the 11 year old subjects, the second series to the running of the 17-year old subjects. For each trial, the difference between the theoretically correct measurement and the *test measurement* (be it for the inherent variability or the systematic variability) was computed. A mean absolute difference score and a standard deviation value of the difference scores was then computed over all ten trials; finally, an overall mean absolute difference score and an overall standard deviation value of the difference scores was computed over all tapes. The resulting overall mean absolute difference scores and overall standard deviation values of the difference scores for both series were as follows:

Inherent variability
(in seconds)

	Overall Mean Difference	Overall Standard Deviation of Difference
Series 1	.698	.440
Series 2	.215	.133

Systematic variability
(in seconds)

	Overall Mean Difference	Overall Standard Deviation of Difference
Series 1	.816	1.540
Series 2	.331	.270

Since about five seconds occurred between elements within a set (and consequently scores within approximately given five-second intervals were deemed correct), such variability argues for caution in our examination of the results. This may not be too relevant, however, if most of the 720 responses in question were made beyond the maximum overall mean difference from the boundaries judged to be correct. This calculation was not done.

Two types of analyses were conducted with the data: Analysis of Variance and Linear Regression.

A complete tabular description of results done on the basis of the Analysis of Variance of the data can be found in Appendix 23. All expected results were tested within the Analysis of Variance. Where applicable, results were interpreted conservatively. For repeated measures designs, the Greenhouse and Geiser procedure was applied, and for comparisons, the Tukey test was applied, with interpolated degrees of freedom for borderline results. As shown in Appendix 23, the analysis of variance revealed main effects of Age (F = 12.3009 with 2, 30 df., $p < .01$), Task (F = 45.6271 with 1, 30 df., $p < .01$), and Contrast (F = 15.3403 with 2, 60 df., $p < .01$), and significant interactions of Task by Contrast (F = 12.3677, with 2, 60 df., $p <.01$) and Age by Sex by Task (F = 4.0182, with 2, 30 df., $p < .05$). The Age by Task interaction was not significant (F = 1.6569, with 2, 30 df., $p > .05$). All main effects and two-way interactions will be interpreted within their respective higher order two- and three-way interactions.

Breaking down first the Age by Sex by Task interaction, an analysis of the simple interaction effects of Age by Task at each Sex level revealed the following trends: for females, performance seemed to improve slightly for the Acoustic Categorization task between ages 7, 11 and 17 going from close to 70% correct at age 7 to close to 90% correct at age 17, and seemed to be relatively stationary for the Linguistic Categorization task between the three Age levels remaining around the 60% correct level; for males, performance again seemed to improve slightly for the Acoustic Categorization task between ages 7, 11 and 17 going from close to 70% correct at age 7 to close to 90% correct at age 17, but seemed to improve substantially for the Linguistic Categorization task between the three age levels starting from a low close to 35% correct at age 7, then to close to 60% correct at age 11, up to close to 80% correct at age 17. That simple interaction effect was significant for females only (for females, F = 3.3724, with 2 and 30 df., $p < .05$; for males, F = 2.3001, with 2 and 30 df., $p > .05$). Within the significant simple Age by Task interaction effect for females, the simple effect of Age was significant for the Acoustic Categorization task only (for the Acoustic Categorization task: F = 3.7834, with 2 and 56 df., $p < .05$; for the Linguistic Categorization task: F = 1.5361, with 2 and 56 df., $p > .05$) (see Appendix 23 and Figure 36. Figure 36 represents plots of the percent correct scores for each type of Task level and each Age level used for the two Sex levels employed). An analysis of the simple interaction effects of Age by Sex at each Task level revealed the following trends: for Acoustic Categorization, performance seemed to improve for the three Age levels employed, similarly for males and females from about 70% correct, to close to 80% correct, up to about 90% correct; for Linguistic Categorization, for females performance seemed to remain around the 60% correct level for the three Age groups, whereas for males performance seemed to be at a low about 35% correct level at age 7, rise to close to 60% correct at age 11, up to close to 80% correct at age 17. Statistically, that simple interaction effect was significant for Linguistic Categorization only (for Acoustic Categorization: F = 0.1233, with 2 and 56 df., p > .05; for Linguistic Categorization: F = 6.6116, with 2 and 56 df., p < .01). Beyond the non-significant Age by Sex interaction for Acoustic Categorization, the simple main effect of Age was significant (F = 8.3061, with 2, 56 df., p < .01). The ensuing pair-wise comparisons between Age levels found only the comparisons between Age 11 and Age 17, and Age 7 and Age 17 to be significant (Age 7 versus Age 11: F = 1.7227, with 1 and 56 df., p > .05; Age 11 versus Age 17: F = 7.2116, with 1 and 56 df., p < .05; Age 7 versus Age 17: F = 15.9838, with 1 and 56 df., p < .01). Beyond the non-significant Age by Sex interaction for Acoustic Categorization, the simple main effect for Sex was not significant (F = 0.0025, with 1, 56 df., p > .05). Within the significant Age by Sex interaction for Linguistic Categorization, the simple main effect of Age was significant for males only (for females: F = 1.5361, with 2, 56 df., p > .05; for males: F = 13.6746, with 2, 56 df., p < .01). The ensuing pair-wise comparisons between Age levels found the comparisons between Age 7 and Age 11, and between Age 7 and Age 17 to be significant (Age 7 versus Age 11: F = 7.9739, with 1 and 56 df., p < .05; Age 11 versus Age 17: F = 5.7605, with 1 and 56 df., p > .05; Age 7 versus Age 17: F = 27.2895, with 1 and 56 df., p < .01). Within the significant simple Age by Sex interaction effect for Linguistic Categorization, the simple effect of Sex was significant at age 7 and at age 17 (Age 7: F = 6.1622, with 1 and 56 df., p < .05; Age 11: F = 1.7015, with 1 and 56 df., p > .05; Age 17: F = 5.9660, with 1 and 56 df., p < .05) (see Appendix 23 and Figure 37. Figure 37 represents plots of the percent correct scores for each Sex level and each Age level used for the two Task levels employed).

Figure 36: **Study 3. Simple interaction effects of age by task at each sex level: a. female level, b. male level. (continued on next page)**

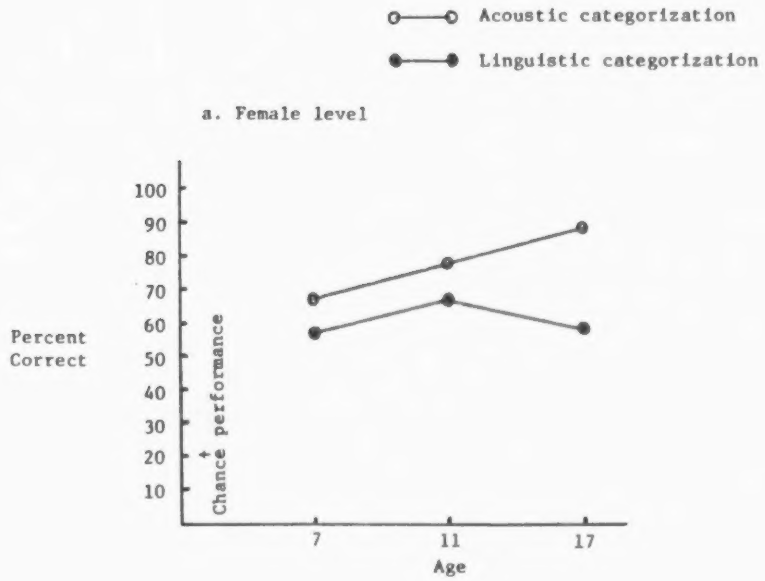


Figure 36: Study 3. Simple interaction effects of age by task at each sex level: a. female level, b. male level. (continued from previous page)

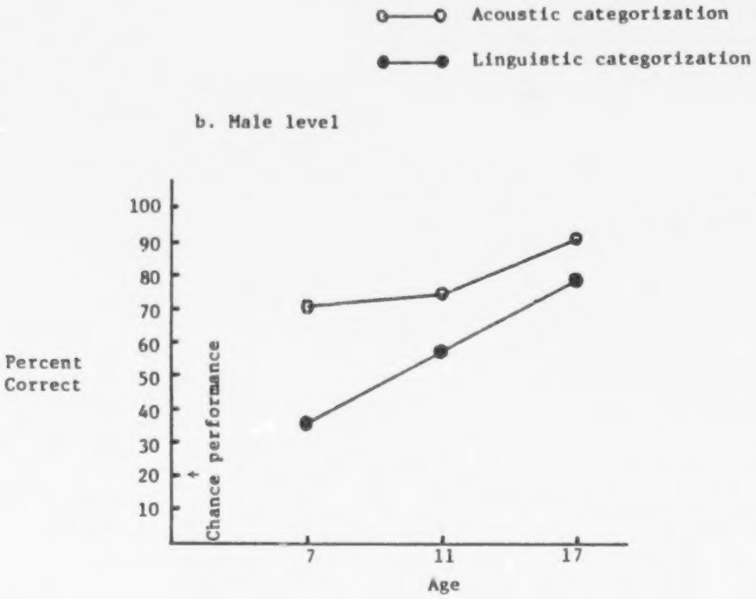


Figure 37: Study 3. Simple interaction effects of age by sex at each task level: a. acoustic categorization level, b. linguistic categorization level (continued on next page)

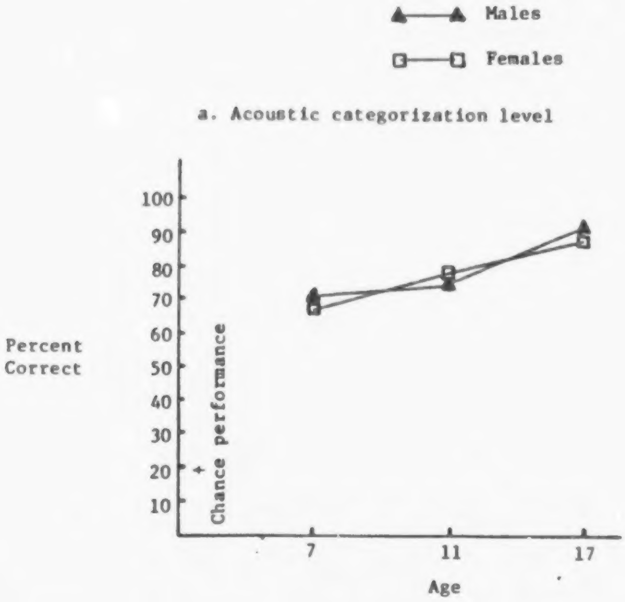
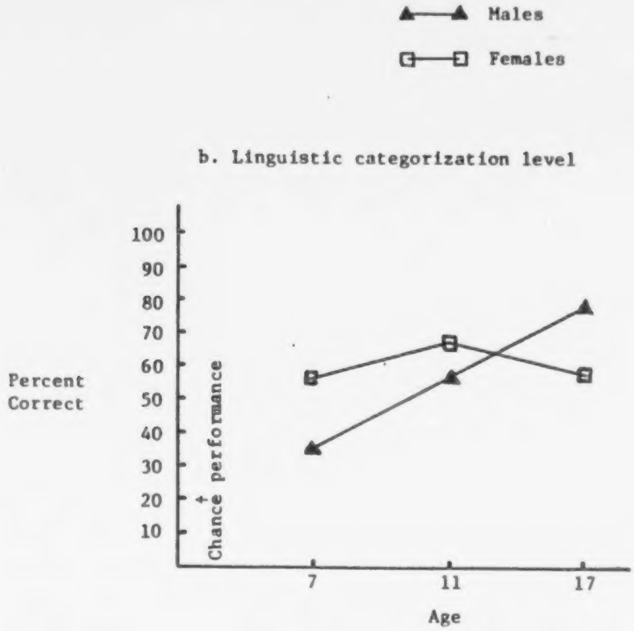


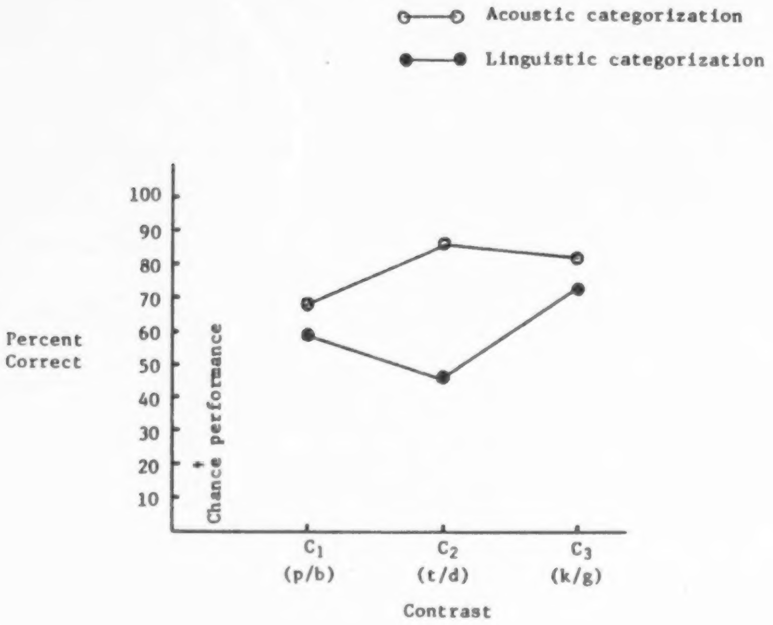
Figure 37: Study 3. Simple interaction effects of age by sex at each task level: a. acoustic categorization level, b. linguistic categorization level (continued from previous page)



Breaking down next the Task by Contrast interaction, an analysis of the simple effects of Contrast at each Task level revealed the following trends: within the Acoustic Categorization task, the t/d contrast seemed to be performed about as well as the k/g contrast, at about 80-85% correct, and much better than the p/b contrast; within the Linguistic Categorization task, the t/d contrast seemed to be performed very poorly, at about 45% correct, and much worse than both the p/b and k/g contrasts. These simple effects were significant at both Task levels (Acoustic Categorization task: F = 10.2675 with 2 and 110 df., $p < .01$; Linguistic Categorization task: F = 16.5240 with 2 and 110 df., $p < .01$). For the Acoustic Categorization task, the ensuing pair-wise comparisons between Contrast levels found that the t/d contrast was performed significantly better than the p/b contrast, and as well as the k/g contrast (p/b versus t/d; F = 19.6237 with 1 and 110 df., $p < .01$; t/d versus k/g: F = 0.25 with 1 and 110 df., $p > .05$); for the Linguistic Categorization task, the ensuing pair-wise comparisons between Contrast levels found that the t/d contrast was performed significantly worse than both the p/b and the k/g contrasts (p/b versus t/d: F = 5.7117 with 1 and 110 df., $p < .05$; t/d versus k/g: F = 32.7488 with 1 and 110 df., $p < .01$) (see Figure 38. Figure 38 represents a plot of the percent correct scores for each Task level and each Contrast level used).

The Linear Regression performed was that of degree of bilingualism with performance on Task and Contrast. The regression was performed on percent correct scores of Tasks and Contrasts standardized at given Ages and Sexes and then pooled across all Ages and Sexes employed. Pooling and standardization were accomplished for the following reasons. Since we had no interest in the relationship between bilingualism and Age or Sex, we decided to pool the data containing these two latter variables, thus increasing the number of cases for the regression. Nevertheless, possible overriding Age and/or Sex effects with degree of bilingualism could, after pooling, hide any existing effects of Task and Contrast. To remove such possible overriding effects, actual scores were converted, before pooling, to standardized scores. A standardized score was, at any given Task by Contrast level, the difference between the mean of the given Age by Sex level of a given

Figure 38: Study 3. Simple effects of task at each contrast level.



subject and the obtained score of that subject divided by the standard deviation of scores of the given Age by Sex level of that subject. This procedure thus reduced all the means for Age and Sex effects to zero (with a standard deviation of scores to 1): this eliminated possible effects of Age and/or Sex, leaving only Task and Contrast effects. These data are given in Table 2. Table 2 shows the degree of linear regression (Simple R value) as well as its significance level (F value) for degree of bilingualism scores with scores on all combinations of the three levels of Contrast (p/b, t/d, and k/g) with the two levels of Task (acoustic categorization, linguistic categorization). From inspection of this table, it can be seen that the linear regressions between degree of bilingualism and Task level by Constrast level revealed no significant correlations for the p/b and t/d contrasts irrespective of Task, but a significant albeit low positive correlation of 0.38 for the k/g contrast on the Linguistic Categorization task only.

STUDY 4: METHOD

In this study sets of eight natural syllables which each contained a change of one consonantal phoneme were presented auditorily to males and females aged 7, 11 and 17 who each contained the whole range of degree of second language knowledge from the completely unilingual to the completely bilingual. The syllables contained one consonant and one vowel. The sets of eight natural syllables presented the consonantal phonemes as a series of phonetic variants of C's in a context of alternating position within the syllable and changing vowel. Three sets of consonantal phonemic contrasts were employed: p/b, t/d and k/g. The above stimuli were the same as those employed for the Linguistic Categorization task of Study 3. Subjects had to repeat every syllable presented within a set and they had to write down every syllable presented within a set. The former task was called Linguistic Categorization with a Repetition response, the latter Linguistic Categorization with a Spelling response. Predictions were made regarding performance on Linguistic Categorization using three modes of response: Button Press response (from the Linguistic

Categorization task data of Study 3), Repetition and Spelling responses (from the data of Study 4). It was hypothesized that, for all response modes employed, performance should be close to chance levels at age 7 and close to perfect at age 17, the improvement occurring at some point between age 11 and 17: for females performance should be close to perfect at age 11, whereas for males performance should still be close to chance levels around age 11.

Table 2:

Study 3. Linear Regression of Degree of Bilingualism with Performance on Task and Contrast

	Contrast					
Task	p/b contrast		t/d contrast		k/g contrast	
	Simple R	F value	Simple R	F value	Simple R	F value
Acoustic Categorization	0.12	0.53 (with 1,34 df)	-0.08	0.20 (with 1,34 df)	0.07	0.17 (with 1,34 df)
Linguistic Categorization	0.09	0.29 (with 1,34 df)	0.09	0.28 (with 1,34 df)	0.38	5.87* (with 1,34 df)

Note. Regression performed on percent correct scores for given Task by Contrast levels standardized at given Ages and Sexes, then pooled across Ages and Sexes.

*p < .05.

Subjects

The subjects were the same as those of Study 3.

Stimuli

The stimuli were the same as used in the Task for the Linguistic Categorization of Speech Sounds of Study 3.

Procedure

The experiment was conducted in a quiet room within the school for ages 7 and 11, or the university for age 17. The Experimenter was the only person present with the subject during actual testing. A visual display of the apparatus and setting is shown in Appendix 24. There were several variations from Study 3. The subject now faced the loudspeaker. On the table to the right of the loudspeaker there was one hollow 14 inch by 14 inch by 29 inch cardboard box, with the hollow side facing away from the subject and toward the experimenter who was seated to the side of the table thus hidden from the subject. The box had a slit on the side between experimenter and subject. The experimenter could thus hear properly what the subject was saying for the first of the two tasks, Linguistic Categorization with a Repetition response, and could thus see what the subject was writing for the second of two tasks, Linguistic Categorization task with a spelling response, but the slit was formed in such a way that the subject could not see the experimenter at any time. The setting for the 6 and 10 year olds required the additional placement of a 4-foot high cardboard box on the floor to the right side of the subject, so that the experimenter could be fully hidden from view. This was not necessary within the 17 year old subjects' room setup. The experimenter held a cord hooked to the manually operable stop/go button of the taperecorder, which controlled the running of the tape, and so could stop the tape at any time. The response keys from Study 3 were eliminated, as was the blind assistant's chair. For the Linguistic Categorization task with a Repetition response, a sheet with numbered lines and a pencil were placed on the table in front of the loudspeaker.

This study was conducted immediately after Study 3. Each subject was seen twice, once for the Linguistic Categorization task with a Repetition response, the other for the Linguistic Categorization task with a Spelling response.

For the Linguistic Categorization task with the Repetition response, the subjects were given the same instructions as they had been given for the Linguistic Categorization task of Study 3, except that they were told to repeat every word as soon as they heard it (instead of pressing the button when the phoneme changed within a set) (complete instructions are given in Appendix 25). The subject sat facing the table while the experimenter sat next to the side of the table, but completely hidden from view (see Appendix 24). The experimenter would record verbatim all the words repeated by subject. At the end of each set, the experimenter would tell the subject that a new set was starting. In the rare case where a subject's voice was too low, he or she was told at this time also, to speak louder. As in the previous study, the subject was given a similar break of five minutes at the end of five sets.

For the Linguistic Categorization task with the Spelling response, the subjects were given the same instructions as they had been given for the Linguistic Categorization task of Study 3, except that they were told to write down every word as soon as they heard it (instead of pressing the button when the phoneme changed within a set) (for complete instructions see Appendix 26). The subject sat facing the table, while the experimenter sat next to the side of the table, but completely hidden from view (see Appendix 24). The experimenter would look through the slit in the cardboard box sitting on the table to ascertain that the subject was writing down each word in its appropriate place. At the end of each set, the experimenter would tell the subject that a new set was starting. In the rare case where the subject was responding too slowly, he or she was told at this time to write down immediately as soon as he/she heard the word. As in Study 3, the subject was given a similar break of five minutes at the end of five sets.

The order of the tasks was fixed: Linguistic Categorization task with the Repetition response followed by Linguistic Categorization task with the Spelling response. The tasks were given in different sessions. The interval between sessions was on the average three to four days.

STUDY 4: DESIGN

There were three age groups (age 7, 11, 17) and two sexes (male, female), with six subjects nested within each of these age-sex cells. Each task consisted of ten trials, four for the p/b contrast, three for the g/k contrast, and three for the d/t contrast. The subject had to repeat every word as soon as he heard it for the Linguistic Categorization task with the Repetition response, and to write down every word, as soon as he heard it, for the Linguistic Categorization task with the Spelling response. Each trial was scored as correct or incorrect. The dependent variable was percent correct for change detected in each type of phoneme contrast (p/b, t/d, or k/g) within each type of task (Linguistic Categorization with a Repetition response, Linguistic Categorization with a Spelling response). Percent correct for change detected in each type of phoneme contrast was computed as

$$\frac{\text{Number of correct trials with given phoneme exemplar}}{\text{Number of existing trials with given phoneme exemplar}} \text{ X } 100$$

A correct response was defined, for both the Linguistic Categorization task with a Repetition response and the Linguistic Categorization task with a Spelling response, as assignment to one phonemic category (using a strict phonemic approach) for all consonantal stimuli in the set up to but excluding the change stimulus, and assignment to a different phonemic category for the consonant of the change stimulus. Vowel assignment had to be changing from stimulus to stimulus. As can be seen, these criteria allowed for actual errors in consonant phoneme category assignment for all stimuli before the change stimulus, or for the change stimulus itself, but were made to be consistent with mode of scoring for Study 3 in which only information of location of change was available. Both the data from the Linguistic Categorization task with a Repetition response, as written out by the experimenter, and the data from the Linguistic Categorization task with a Spelling response, as written out by the subject, were interpreted phonemically (strict phonemic approach), regardless of spelling peculiarities. See Appendix 27 for the complete design.

Because we were interested in performance by Age and Sex on the Linguistic Categorization task across different response modes, the data analysis involved the Linguistic Categorization task (Button Press response) of Study 3, the Linguistic Categorization task with a Repetition response of Study 4, and the Linguistic Categorization task with a Spelling response of Study 4. The analysis was a four-way ANOVA with repeated measures on two factors. This consisted of three levels of age (A) (Ages 7, 11, 17), two levels of sex (X), and six subjects nested within each age-sex combination. The repeated factors were: Type of Task (T), which consisted of three levels, Linguistic Categorization with a Button Press response, Linguistic Categorization with a Repetition response, Linguistic Categorization with a Spelling response, and type of Phonemic Contrast (C), which consisted of three levels, p/b, t/d and k/g. The order of Tasks was fixed as follows: Linguistic Categorization with a Button Press response, followed by Linguistic Categorization with a Repetition response, followed by Linguistic Categorization with a Spelling response. The factors not analyzed for were counterbalanced or randomly assigned. The direction of list presented, forward (trials 1 to 10) or backward (trials 10 to 1), was counterbalanced. The other factors not analyzed for were randomly assigned. Within all tasks, these were the same as all factors randomly assigned within the Linguistic Categorization task of Study 3.

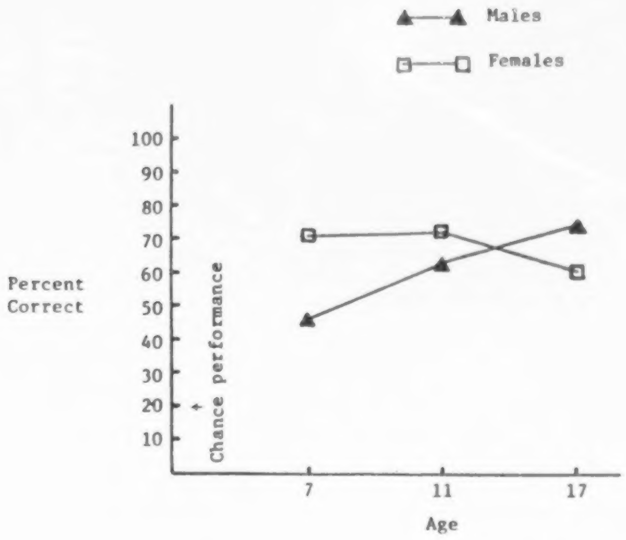
STUDY 4: RESULTS

A complete tabular description of results done on the basis of the Analysis of Variance of the data can be found in Appendix 28. All expected results were tested within the Analysis of Variance. Where applicable, results were interpreted conservatively. For repeated measures designs, the Greenhouse and Geiser procedure was applied, and for comparisons, the Tukey test was applied. As shown in Appendix 28, the analysis of variance revealed main effects of Task ($F = 5.5976$ with 2, 60 df., $p < .05$), and Contrast ($F = 31.0476$ with 2, 60 df., $p < .01$), and a significant Age by Sex interaction ($F = 7.6153$ with 2, 30 df., $p < .01$).

Further analyses of the significant main effects were not conducted. Breaking down the Age by Sex interaction, an analysis of the simple main effects of Age at each Sex level revealed the following trends: for females, performance seemed to be relatively stationary between the three

Age levels hovering around the 65% correct level; for males, performance seemed to improve between the three age levels starting from a low close to 45% correct at age 7, then to close to 60% correct at age 11, up to close to 75% correct at age 17. That simple main effect was significant for males only (for females, $F = 1.8354$ with 2, 30 df., $p > .05$; for males, $F = 7.9736$ with 2, 30 df., $p < .01$). The ensuing pairwise comparisons between Age levels for males found only the comparison between Age 7 and Age 17 to be significant (Age 7 versus Age 11, $F = 5.4263$ with 1, 30 df., $p > .05$; Age 11 versus Age 17, $F = 2.7054$ with 1, 30 df., $p > .05$; Age 7 versus Age 17, $F = 15.7947$ with 1, 30 df., $p < .01$) (see Appendix 28 and Figure 39. Figure 39 represents a plot of the percent correct scores for each Age level used and for the two sex levels employed). An analysis of the simple main effect of Sex at each Age level revealed the following trends: at age 7, male performance seemed to be inferior to female performance by a difference of about 25% correct, at age 11, by a difference of about 10% correct, while at age 17, male performance seemed to be superior to female performance by a difference of about 15% correct. That simple main effect was significant for Age 7 only (for Age 7, $F = 12.5232$ with 1, 30 df., $p < .01$; for Age 11, $F = 2.2994$ with 1, 30 df., $p > .05$; for Age 17, $F = 3.6853$ with 1, 30 df., $p > .05$) (see Appendix 28 and figure 39).

Figure 39: **Study 4. Interaction of age by sex.**



STUDY 3 & STUDY 4: DISCUSSION, PART I

As mentioned in the Introduction, stimuli to be categorized within the Task for the Acoustic Categorization of Speech Sounds were assumed to contain a relatively easy to classify invariant, whereas the stimuli to be categorized within the Task for the Linguistic Categorization of Speech Sounds were assumed not to contain a relatively easy to classify invariant property. The two types of categorization were hypothesized to require two separate processes, only the latter of which was postulated to be linguistic in nature. In Study 3, the difference in developmental pattern for the Acoustic Categorization task versus the Linguistic Categorization task observed in females supports a hypothesis of the existence of two different mechanisms operating for the processing of speech sounds. As regards the nature of the different processes that are at work, there are four sets of findings in Study 3, and a replication with different response modes of part of two of these in Study 4, indicating that the difference observed is along non-linguistic/linguistic dimensions. The findings are the following. With regard to the specific pattern of development of presumed acoustic versus linguistic modes of categorization, Study 3 fulfilled in part our expectations. Contrary to expectations, the Acoustic Categorization task did exhibit a developmental trend across the three age groups observed. The improvement in performance seemed to occur between ages 11 and 17. As expected, however, with regard to sex differences in presumed acoustic versus linguistic modes of categorization, both males and females developed similarly for the Acoustic Categorization task. Within the Linguistic Categorization task, again as expected, there were marked differences in the mode of development of males versus females, although the actual pattern fulfilled our expectations only in part. In fact, females exhibited no development in their performance on the linguistic Categorization task but males did show a significant improvement somewhere after age 7. These last two findings were confirmed, using besides the Button Press response mode of Study 3, Repetition and Spelling responses, in Study 4. The predicted inferiority of males over females in the Linguistic Categorization task at younger ages was present in both Studies 3 and 4, although at age 7 rather than at age 11. An unexpected superiority of males over females in the Linguistic Categorization task at age 17 was present in Study 3, but was not found again in Study 4. In summary, there are a number of positive elements to the patterns of development for Acoustic Categorization versus Linguistic Categorization, and to the pattern of sex differences within the latter two Tasks. The positive finding, in males, of a pattern of development for the Linguistic Categorization task resembling that suspected for complex stimuli, repeated across three response modes, is encouraging; that females perform well and do not improve on this task may suggest that the male pattern could have occurred earlier. We have, however, no explanation for the improvement in performance on the Acoustic Categorization task between the ages of 11 and 17. Also encouraging is the expected similarity in performance for the Acoustic Categorization task, between males and females, as expected in the development of non-linguistic stimuli. Finally, the inferiority of young males compared to young females on the Linguistic Categorization task, repeated across three response modes, expected in the development of linguistic stimuli, also bolsters the argument for linguistic dimensions in the Linguistic Categorization task.

The third set of findings of Study 3 was unexpected, but as will be shown later, supportive of a non-linguistic/linguistic processing hypothesis for the Acoustic versus the Linguistic Categorization task; we refer here to the finding that, within the Linguistic Categorization task only, the t/d contrast was performed significantly worse than both the p/b and the k/g contrasts.

The fourth set of positive findings in Study 3 was the fact that performance only on the Linguistic Categorization task and only on the k/g contrast was significantly positively correlated with degree of bilingualism and all other Contrast by Degree of bilingualism scores were not correlated, regardless of Task. Although the positive correlation was not too high, this different pattern of correlation of degree of bilingualism with Contrasts for the two Tasks, was again predicted by a non-linguistic/linguistic difference for the two Tasks.

STUDY 3 & 4: ADDITIONAL ANALYSES

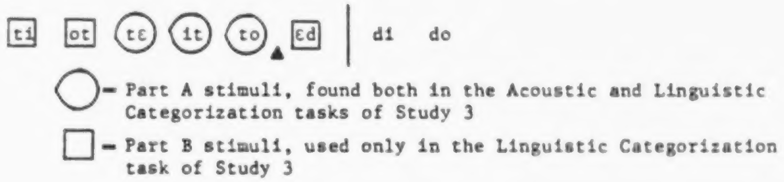
Additional analyses were conducted in an attempt to strengthen and shed further light on two sets of findings: the finding that, in Study 3, within the Linguistic Categorization task only, the t/d contrast was performed significantly worse than both the p/b and the k/g contrasts (this will hereafter be referred to as the t/d Effect), and the finding that, in Study 3, performance only on the Linguistic Categorization task and only on the k/g contrast was significantly positively correlated with degree of bilingualism and all other Contrast by Degree of bilingualism scores were not correlated, regardless of Task (this will hereafter be referred to as the Bilingualism Effect). To strengthen these findings, we attempted to remove possible artifacts. To shed further light on them, for reasons which will become clearer later on, we explored the nature of the phonemic structure of the language or languages involved.

The t/d Effect

Elimination of possible stimulus artifacts: different stimulus sets

We will attempt to remove two possible stimulus artifacts. The first such artifact was that the Acoustic Categorization task of Study 3 contained only a subset of the VC and CV syllables used for the Linguistic Categorization task. It should be possible to eliminate such a confound by separating out within the Linguistic Categorization task, the stimuli used in the Acoustic Categorization task from the stimuli not used in the Acoustic Categorization task. Comparison of performance on the two subsets of stimuli within the Linguistic Categorization task should indicate whether the differential pattern of performance for the t/d contrast (Figure 38) was an artifact of the differences in stimuli used for the two Categorization tasks. If there were such an artifact, the pattern of performance for the stimuli used for the Acoustic Categorization task should resemble the results shown in Figure 38 for the Acoustic Categorization task; the pattern of performance for the stimuli used only in the Linguistic Categorization task should resemble the results in Figure 38 for the Linguistic Categorization task. If the difference between tasks was not a result of such an artifact, performance for both subsets of stimuli should resemble the pattern of performance for the Linguistic Categorization task in Figure 38. Such a comparison of subsets of stimuli could not be accomplished within Study 3 trials, because the Button Press at change of phoneme for each trial provided no information about how each individual stimulus was responded to within a trial. However, this comparison could be made with the data of Study 4 where the Repetition and the Spelling of stimuli on the Linguistic Categorization of stimuli was required. It will be recalled that the stimuli for Study 4 were the same as those used for the Linguistic Categorization task of Study 3. To assess the possible differences between the two subsets of stimuli, then, the Repetition data of Study 4 were further analyzed.

Within the Linguistic Categorization task with a Repetition response, each session consisted of ten trials, four for the p/b contrast, three for the g/k contrast, and three for the t/d contrast. For the additional analyses, each trial was divided into part A and part B. Stimuli for part A were those that, compared to Study 3, were found both in the Acoustic and Linguistic Categorization tasks of Study 3, stimuli for part B were those that, compared to Study 3, were only found in the Linguistic Categorization task of Study 3. Within each trial, stimuli belonging to each part were intermixed with those belonging to the other part as shown in the following example:


ti
ot
tɛ
it
to
ɛd
di
do
Part A stimuli, found both in the Acoustic and Linguistic Categorization tasks of Study 3
Part B stimuli, used only in the Linguistic Categorization task of Study 3

Classification into part A and B and subsequent scoring was done only for stimuli within each trial up to and including the stimulus occurring after the change stimulus. Each individual repetition was first labelled as correct or incorrect. For example, if the subject said pa and the stimulus was actually ta, the repetition was labelled incorrect. If all repetitions within a part were labelled correct, that part was scored as correct. If there were one or more incorrect repetitions within a part, that part was scored as incorrect. As before, a strict phonemic interpretation, regardless of spelling peculiarities, was used as the criterion for what was judged to have been repeated. The dependent variable was percent correct in each part (A or B) in each type of phoneme contrast (p/b, t/d, or k/g). As before, percent correct was computed as:

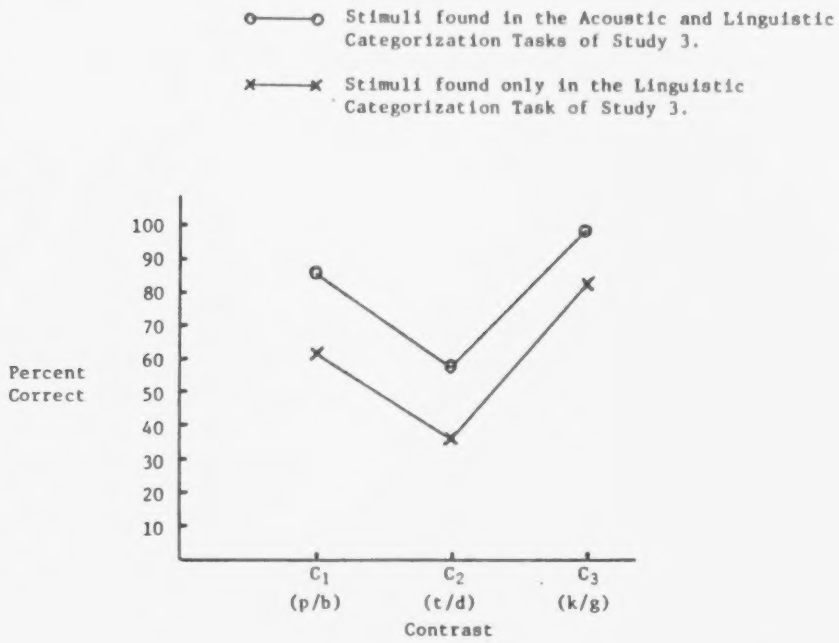
$$\frac{\text{Number of correct trials with given phoneme exemplar}}{\text{Number of existing trials with given phoneme exemplar}} \times 100$$

The post-hoc analysis was a four-way ANOVA with repeated measures on two factors. This consisted of three levels of age (A) (Ages 7, 11, 17), two levels of sex (X), and six subjects nested within each age-sex combination. The repeated factors were: Parts (P), which consisted of two levels, part A and part B; and type of Phonemic Contrast (C), which consisted of three levels, p/b, t/d, and k/g. The factors not analyzed for were the direction of list presented, forward (trials 1 to 10) or backward (trials 10 to 1) (counterbalanced) and, within each Part, the type of phonemic contrast (p/b, g/k, d/t) within a set (randomly assigned).

A complete tabular description of results done on the basis of the Analysis of Variance of the data can be found in Appendix 29. All expected results were tested within the Analysis of Variance. Where applicable, results were interpreted conservatively. For repeated measures designs, the Greenhouse and Geiser procedure was applied, and for comparisons, the Tukey test was applied. Because this analysis only concerns effects related to the factor Contrast at each Part level, only effects related to these will be described. As shown in Appendix 29, the analysis of variance revealed main effects of Part ($F = 49.8153$, with 1, 30 df., $p < .01$), and Contrast ($F = 36.9047$, with 2, 60 df., $p < .01$). Since there was no significant interaction of Part by Contrast ($F = 0.5482$, with 2, 60 df., $p > .05$) or any other higher order interactions involving the factors of Part by Contrast, the main effect of Contrast could be looked into simply.

An analysis of the trends shown by each Contrast revealed, for both Parts A and B, an at least 25% correct performance decrement for the t/d contrast compared to p/b and k/g. The pairwise comparisons between Contrast levels found these trends to be significant (p/b versus t/d, $F = 23.8879$, with 1, 60 df., $p < .01$; t/d versus k/g, $F = 73.3185$ with 1, 60 df., $p < .01$) (see Appendix 29 and Figure 40. Figure 40 represents a plot of the percent correct scores for each Contrast level used and for the two Parts employed).

Figure 40: **Study 4. Additional analyses of repetition data: Part by contrast level**



It can be seen then that the t/d Effect observed in the Linguistic Categorization task of Study 3 is replicated here both for the subset of stimuli found in the Acoustic and Linguistic Categorization Tasks of Study 3 and for the subset of stimuli found only in the Linguistic Categorization Task of Study 3. This finding indicates that the t/d Effect observed in the Linguistic Categorization Task of Study 3 was not an artifact of the larger sets of stimuli used in the Linguistic Categorization task.

Elimination of possible stimulus artifacts: different phonetic forms

To be even more certain that the above conclusion is correct, one would still have to verify that the actual phonetic forms found in the Acoustic Categorization Task of Study 3 were the same as those found for the same subset of stimuli in the Linguistic Categorization Task of Study 3. Such a verification for a second possible artifact was made, as shown in Tables 3 and 4. Table 3 shows the phonetic forms found within the Acoustic Categorization task of Study 3 for the stimuli used in both the Acoustic and Linguistic Categorization tasks of Study 3. Table 4 shows the phonetic forms found within the Linguistic Categorization task of Study 3 for the stimuli used in both the Acoustic and Linguistic Categorization tasks of Study 3. In both tables the phonetic forms are shown for all phonemes possibly employed (/p/, /b/, /t/, /d/, /k/, /g/), in both syllabic forms possibly used (CV, VC), and in all of the three vocalic contexts possibly used (ε, i, o). The phonemes were transcribed by two French Canadian phonetically-trained linguists. The transcriptions were done for stimuli up to and including the change stimulus within each trial for all tapes used in Study 3. Only the linguists' phonemically correct transcriptions were tabulated (the error rate was around 11%).

Although the phonetic forms for the subset of stimuli found within the Linguistic Categorization task (Table 4) were less numerous than for the stimuli found in the Acoustic Categorization Task (Table 3), from inspection of these tables it can be seen that those forms found were identical. The occurrence of fewer forms is understandable, because these stimuli were only a subset of the stimuli for the Linguistic Categorization task, whereas they constituted the total stimulus set for the Acoustic Categorization task.

Table 3:

/p/, /b/, /t/, /d/, /k/, /g/ Stimuli used in the Acoustic and Linguistic Categorization Tasks of Study 3: Phonetic Forms Found Within the Acoustic Categorization Task

	Syllabic Form					
	CV			VC		
	Vocalic context			Vocalic context		
Phoneme	ε	i	o	ε	i	o
p	p, p^{h}	p, p^{h}		p, p^{h}		p, p^{h}
b	b	b, b^{h}		b		b
t	t, t^{h}		t, t^{h}		t	
d	d, d^{h}		d, d^{h}		d	
k			k, k^{h}	k	k	k
g			g, g^{h}	g	g	g

Note. Transcriptions made by two French Canadian phonetically-trained linguists. Transcriptions done for stimuli up to and including the change stimulus within a set. Only phonemically correct responses tabulated.

Table 4:

/p/, /b/, /t/, /d/, /k/, /g/ Stimuli used in the Acoustic and Linguistic Categorization Tasks of Study 3: Phonetic Forms Found Within the Linguistic Categorization Task

	Syllabic Form					
	CV			VC		
	Vocalic context			Vocalic context		
Phoneme	ɛ	i	o	ɛ	i	o
p	p			p, pʰ		p
b		b		b		b
t	t, tʰ		t, tʰ		t	
d	d				d	
k			k, kʰ	k		
g			g, gʰ	g	g	

Note. Transcriptions made by two French Canadian phonetically-trained linguists. Transcriptions done for stimuli up to and including the change stimulus within a set. Only phonemically correct responses tabulated.

Explanation of the t/d Effect

We will compare here the phonetic forms found in Study 3 with forms found from a more careful selection of typical Montreal French. We will present evidence which shows that the phonetic forms found in Study 3 did not always represent typical Montreal French, and that this was particularly true for the t/d phonemic contrast. We will demonstrate, furthermore, that the pattern of relatively more severe violations for the t/d phonemic contrast compared to the other two contrasts was found both for the stimuli within the Acoustic Categorization task and for the stimuli within the Linguistic Categorization task. The fact that performance only on the Linguistic Categorization task was similarly affected by this pattern of violations suggests that only the Linguistic Categorization task involved a process of classification of the phonetic forms of the given language into existing phonemic classes.

The linguist Benoît Jacques, for his Ph.D. thesis on the phonetics of Montreal French (Jacques, 1983) selected tens of words which contained phonetic variants of /p/, /b/, /t/, /d/, /k/, /g/ with the vowels ɛ, i, o in CV and VC contexts. He had them uttered by a number of Montreal speakers. He then classified the results phonetically, using a strict phonemic approach. The results are shown in Table 5. Table 5 shows the phonetic forms he found in Montreal French. The phonetic forms are shown for all phonemes possibly employed (/p/, /b/, /t/, /d/, /k/, /g/), in both syllabic forms possibly used (CV, VC), and in all of the three vocalic contexts possibly used (ɛ, i, o).

Table 5:

/p/, /b/, /t/, /d/, /k/, /g/ Stimuli:
Phonetic Forms Found in Montreal French
(on the basis of data gathered for Jacques, 1983:
courtesy of the author)

	Syllabic Form[a]					
	CV			VC		
	Vocalic context			Vocalic context		
Phoneme	ɛ	i	o	ɛ	i	o
p	p, p^h	p, p^h	p, p^h	p, p^h	p, p^h	p, p^h
b	b	b	b	b, $\underset{\smile}{bb}_o$	b, $\underset{\smile}{bb}_o$	b, $\underset{\smile}{bb}_o$
t	t, t^h	t_s, (t)	t, t^h	t, t^h	t, t^h	t, t^h
d	d	d_z, (d)	d	d, $\underset{\smile}{dd}_o$	d, $\underset{\smile}{dd}_o$	d, $\underset{\smile}{dd}_o$
k	k, k^h	k, k_x, (k^h)	k, k^h	k, k^h	k, k^h	k, k^h
g	g	g, (g_γ)	g	g, $\underset{\smile}{gg}_o$	g, $\underset{\smile}{gg}_o$	g, $\underset{\smile}{gg}_o$

[a] ( ) indicates rare occurrence.

Another sampling of the phonetic variants of /p/, /b/, /t/, /d/, /k/, /g/ with the vowels ɛ, i, o in CV and VC contexts in Montreal French was carried out by the Experimenter by selecting one hundred 4 to 5 word phrases or sentences at random from all pages within one issue of the Montreal French newspaper *La Presse* (see Appendix 30 for list). The voice of a native francophone Montrealer was tape-recorded while he read them. Recording was done on a SONY-6S reel to reel tape recorder; the microphone used was SONY Cardioid, F-25 Implow. Tape speed was 7½ inches per second. Tape used was 1.0 mil., low noise polyester tape. One word was selected at random from each phrase or sentence (see Appendix 31 for words selected). The words thus selected were transcribed both phonetically and phonemically by a linguist with a strict phonemic approach (see Appendix 32 for result of transcription). Listening level was selected by the linguist. The results are found in Table 6. Table 6 shows the phonetic forms found by the Experimenter in Montreal French. The phonetic forms are shown for all phonemes possibly found (/p/, /b/, /t/, /d/, /k/, /g/), in both syllabic forms possibly used (CV, VC), and in all of the three vocalic contexts possibly used (ɛ, i, o).

We will compare the phonetic structure of the Montreal French syllables classified in Tables 5 and 6 with the phonetic structure of the syllables used in Study 3 for each trial up to and including the change stimulus. The comparison will be done separately for the stimuli of the Acoustic Categorization task (Table 3), the same stimuli used in the Linguistic Categorization task (Table 4), and the stimuli used only in the Linguistic Categorization task (Table 7). Table 7 shows the phonetic forms found within the Linguistic Categorization task of Study 3 for stimuli used only in the Linguistic Categorization task of that study. The phonetic forms are shown for all phonemes possibly employed (/p/, /b/, /t/, /d/, /k/, /g/), in both syllabic forms possibly used (CV, VC), and in all of the three vocalic contexts possibly used (ɛ, i, o). The phonemes were transcribed by two French Canadian phonetically-trained linguists. The transcriptions were done for stimuli up to and including the change stimulus within each trial for all Linguistic

Categorization tapes used in Study 3. Only the linguists' phonemically correct transcriptions were tabulated (the error rate was around 11%). An examination of Tables 5 and 6 shows that the two studies of the phonetics of Montreal French are in agreement with respect to the types of phonetic forms found. For reasons to be described further on, we will use each of these two tables as a different index of typical Montreal French.

Table 6:

/p/, /b/, /t/, /d/, /k/, /g/ Stimuli:
Phonetic Forms Found in Montreal French
(From a Random Sampling of Words in Common Usage
From an Issue of *La Presse*)

	Syllabic Form[ab]					
	CV			VC		
	Vocalic context			Vocalic context		
Phoneme	ε	i	o	ε	i	o
p	p	p	-	-	-	-
b	b	b	-	-	-	-
t	-	t_s	t	-	t	-
d	-	d_z, (d)	-	d	-	-
k	k	k	-	k	k	-
g	-	-	-	-	-	-

[a] ( ) indicates rare occurrence.

[b] - indicates no such CVs or VCs found in this particular sample.

Within each phoneme, we have decided to consider two types of violations as important: the existence in Study 3 of phonetic forms which do not appear to be part of Montreal French, and the absence of phonetic forms which appear to be a frequent part of Montreal French. The assumption underlying these expected types of violations is that when a subject is faced with a categorization task, the experimental stimuli will be judged against an internal set of representatives of the category in question. This internal set is assumed to consist of prototypical cases. These assumptions are working extrapolations based on the findings presented in Mervis and Rosch (1981) regarding categorization. For example, "correct classification of novel exemplars is strongly negatively correlated with degree of distortion of the exemplar from the prototype pattern." (Mervis & Rosch, 1981, p. 98), and "When subjects are asked to indicate which of a series of categorically related stimuli have been seen previously, percentage of false recognition responses and degree of confidence that the (novel) pattern has been seen previously are both negatively correlated with degree of distortion from the prototype..." (Mervis & Rosch, 1981, p. 98). We have decided to consider in this case the prototypical cases as the spectrum of phonetic forms which are found most frequently in Montreal French. The data of Table 5 appears to us to be a better representation of the spectrum of phonetic forms and thus will be used to test violations of form (that is, the occurrence of incorrect forms in Study 3 stimuli). The reason for this is the following.

Table 7:

/p/, /b/, /t/, /d/, /k/, /g/ Stimuli Used Only in the Linguistic Categorization Task of Study 3: Phonetic Forms Found Within These Stimuli

	Syllabic Form					
	CV			VC		
	Vocalic context			Vocalic context		
Phoneme	ɛ	i	o	ɛ	i	o
p			p, p^h		p^h, p	p
b			b, b^h			
t		t, t^h		t	t	t
d				d		d
k	k, k^h	k, k^h				k
g	g	g, g_γ				g

Note. Transcriptions made by two French Canadian phonetically-trained linguists. Transcriptions done for stimuli up to and including the change stimulus within a set. Only phonemically correct responses tabulated.

Benoît Jacques did a large scale study of pre-selected CVs and VCs; therefore the phonetic forms he found should be excellent representations of the distribution of form within these CVs and VCs. However, since he pre-selected his CVs and VCs and did not take them from a random selection of language as it is spoken and heard, the phonetic forms are not necessarily good representations of the frequency of occurrence of these forms. Similarly, the data of Table 6 appears to us to be a better representation of frequent phonetic forms and thus will be used to test violations of frequency (that is, the occurrence of missing forms in Study 3 stimuli). The reason for this is the following. The Experimenter did a small-scale study of a random sampling of language as it is commonly spoken and heard; therefore the phonetic forms found should be excellent representations of the frequency distribution of phonetic forms within CVs and VCs found. However, since it was a small-scale study, it probably resulted in an underrepresentation of the distribution of the spectrum of forms within these CVs and VCs.

A list of these violations is presented in Table 8. Table 8 shows the violations of the phonetic structure of the Montreal French phonemes /p/, /b/, /t/, /d/, /k/, /g/ for the stimuli of Study 3. Both violations of form (Incorrect phonetic form), and violations of frequency (Missing phonetic form) are shown. The Study 3 stimuli looked at were broken down into those used in the Acoustic and Linguistic Categorization tasks and those used only in the Linguistic Categorization task. For those stimuli used in the Acoustic and Linguistic Categorization tasks, these were further broken down into the subset of stimuli found within the Acoustic Categorization task and the subset of stimuli found within the Linguistic Categorization task. For the stimuli resulting from such a breakdown, the corresponding phonetic forms, as listed in Tables 3, 4 and 7, were analyzed. For reasons mentioned previously, the occurrence of incorrect phonetic forms in Study 3 stimuli were judged against corresponding CVs and VCs in Montreal French as described by Benoît Jacques' work (Table 5) and the occurrence of missing phonetic forms in Study 3 stimuli were judged against corresponding CVs and VCs in Montreal French as described by the Experimenter's small study (Table 6).

Table 8:

List of Violations of the Phonetic Structure of Montreal French Phonemes /p/, /b/, /t/, /d/, /k/, /g/ for Stimuli of Study 3

	Study 3 Stimuli		
	Used in the Acoustic and Linguistic Categorization Tasks		Used Only in the Linguistic Categorization Task
	Phonetic Forms Found		Phonetic Forms Found
Violation	Within the Acoustic Categorization Task	Within the Linguistic Categorization Task	Within These Stimuli
Incorrect Phonetic Form	(Tables 3 vs 5)	(Tables 4 vs 5)	(Tables 7 vs 5)
	b^hi $d^h\varepsilon$ d^ho g^ho	g^ho	b^ho t^hi
Missing Phonetic Form	(Tables 3 vs 6)	(Tables 4 vs 6)	(Tables 7 vs 6)
			t_si

Note. Study 3 stimuli examined were those up to and including the change stimulus within a set.

The data will be interpreted by examining the results from the first column of Table 8 on the one hand, (that is, all the stimuli used in the Acoustic Categorization task), and those from the second and third columns combined on the other hand, (that is, all the stimuli used in the Linguistic Categorization task). We will now look at the total number of violations (of form and frequency combined) for each type of phonemic contrast (p/b, t/d, k/g) within each type of task (Acoustic Categorization, Linguistic Categorization). Within the Acoustic Categorization task, it will be observed that there were more violations for the t/d contrast (namely two: $d^h\varepsilon$ and d^ho), than for either the p/b or k/g contrasts (one of each: b^hi, g^ho). Within the Linguistic Categorization task, it will be observed that there were also more violations for the t/d contrast (namely two: t^hi and t_si), than for either the p/b or k/g contrasts (one of each: b^ho, g^ho). This pattern of violations for the t/d contrast compared to the other two contrasts is similar to the relatively poorer performance for the t/d contrast compared to the other two contrasts in the Linguistic Categorization task of Study 3. This leads us to conclude that when subjects were performing the Linguistic Categorization task of Study 3 they did indeed try to categorize the phonetic forms presented into their respective phonemic classes, and thus performed relatively more poorly when the phonetic forms presented (that is, those for the t/d contrast) violated more severely their internal standards for the members of the category in question. However, because performance on the t/d contrast within the Acoustic Categorization task of Study 3 was as good or better than the other two contrasts despite the above-mentioned pattern of violations, we are led to conclude that when subjects were performing the Acoustic Categorization task of Study 3 they did not try to categorize the phonetic forms presented into their respective phonemic classes because had they done so they should have again performed relatively more poorly on the t/d contrast compared to the other two contrasts. Instead, they resorted to another mode of classification which produced better or equivalent performance for the t/d contrast compared to the other two contrasts.

Before concluding the section on the t/d Effect a brief post-hoc explanation is in order to justify the appearance in our experimental stimuli of Study 3 of violations of the structure of Montreal French. The Experimenter, who is not a speaker of Montreal French, was the one who controlled the apparatus recording the stimuli and thus involuntarily set the criteria of acceptability of the stimuli. Also, the speaker who spoke the stimuli, on later questioning, revealed a history of partial high-school attendance of a school taught by teachers from France; as well, blind to the Experimenter's results, he spontaneously confessed to a predisposition to easily adopt the manner of speech of people he found himself with (in that case, the Experimenter's).

The Bilingualism Effect

Elimination of possible stimulus artifact: different stimulus sets

As for the t/d Effect, one possible artifact was that the Acoustic Categorization task of Study 3 contained only a subset of the VC and CV syllables used for the Linguistic Categorization task. In attempting to eliminate this possible stimulus artifact, for the parallel line of argumentation cited in the analogous section on the t/d Effect (page 69), we again made use of the Repetition data of Study 4 and divided the data up to and including the change stimulus into the subset of stimuli used both in the Acoustic and Linguistic Categorization tasks of Study 3 and the subset of stimuli used only in the Linguistic Categorization task of Study 3. Scoring was as described on page 69. We then calculated the linear regression between degree of bilingualism and performance on the k/g contrast for each subset of stimuli contained in the Repetition data of Study 4. The regression was performed on percent correct scores of the k/g contrast for both subsets of stimuli, the scores being standardized at given Ages and Sexes then pooled across all Ages and Sexes employed. Pooling and standardization were accomplished in a parallel manner and for the same reasons as described on pages 62 and 63. The data on linear regression are given in Table 9. Table 9 shows the degree of linear regression (Simple R value) and its significance level (F value) for degree of bilingualism scores with scores on the two levels of Subset of Stimuli (Found in Acoustic and Linguistic Categorization tasks of Study 3, Found only in Linguistic Categorization task of Study 3) for the k/g Contrast. From inspection of this table, it can be seen that the linear regression between degree of bilingualism and the k/g Contrast for the subset of stimuli found in the Acoustic and Linguistic Categorization tasks of Study 3 was close to zero, and that it was a significant low positive correlation of 0.36 for the subset of stimuli found only in the Linguistic Categorization task of Study 3. Significant low positive correlations for both subsets of stimuli would have indicated that there was no stimulus artifact in the original Study 3 low positive correlation for the k/g contrast within the Linguistic Categorization task only. Examination of raw scores for the subset of stimuli found both in the Acoustic and Linguistic Categorization tasks of Study 3 in the Repetition data of Study 4 as looked at in this section, showed these to contain a large proportion of perfect scores (94%). This explained the near-zero correlation, and in conclusion, one cannot say whether the Linguistic Categorization task per se or characteristics of stimuli used in the subset of stimuli used only in the Linguistic Categorization task were responsible for the positive correlation of performance on k/g with degree of bilingualism only for the Linguistic Categorization task in Study 3.

Table 9:

Study 4. Additional Analyses of Repetition Data: Linear Regression of Degree of Bilingualism with Performance on k/g Contrast for Subsets of Stimuli Contained

	Contrast	
Subset of Stimuli	k/g contrast	
	Simple R	F value
Found in Acoustic and Linguistic Categorization tasks of Study 3	0.09	0.28 (with 1,34 df)
Found Only in Linguistic Categorization task of Study 3	0.36	5.10* (with 1,34 df)

Note. Regression performed on percent correct scores for k/g Contrast by given Subset of Stimuli levels standardized at given Ages and Sexes, then pooled across Ages and Sexes.

* $p < .05$.

Attempt at explaining the Bilingualism Effect

In order to explain the finding that within the Linguistic Categorization task of Study 3, degree of bilingualism was positively correlated with performance on the k/g contrast, but was not correlated with performance on the p/b or the t/d contrasts, we compared the phonetic forms found in Montreal French with those found in Montreal English for the CVs and VCs employed within the Linguistic Categorization task to try to show that interference and facilitation between two linguistic systems could have produced an advantage in bilinguals for the k/g Contrast and none for the p/b and the t/d Contrasts.

In order to have comparative samples of Montreal French and Montreal English, we conducted a small study of Montreal English similar to the one for Montreal French described on page 73. (There was no study of Montreal English comparable to that described for Montreal French on pages 72 and 73). The study involved a sampling of the phonetic variants of /p/, /b/, /t/, /d/, /k/, /g/ with the vowels ɛ, i, o in CV and VC contexts in Montreal English. It was carried out by the Experimenter by selecting one hundred 4 to 5 word phrases or sentences at random from all pages within one issue of the Montreal English newspaper *The Gazette* (see Appendix 33 for list). The voice of a native anglophone Montrealer was tape-recorded while he read them. Recording was done on an AKAI (GX-400D.SS) reel to reel tape recorder; the microphone used was SONY Cardioid, F-25 Implow. Tape speed was 7½ inches per second. Tape used was 1.0 mil., low noise polyester tape. One word was selected at random from each phrase or sentence (see

Appendix 34 for words selected). The words thus selected were transcribed both phonetically and phonemically by a linguist with a strict phonemic approach (see Appendix 35 for result of transcription). Listening level was selected by the linguist. The results are found in Table 10. Table 10 shows the phonetic forms found by the Experimenter in Montreal English. The phonetic forms are shown for all phonemes possibly found (/p/, /b/, /t/, /d/, /k/, /g/), in both syllabic forms possibly used (CV, VC), and in all of the three vocalic contexts possibly used (ε, i, o).

For CVs and VCs identical to those employed in the Linguistic Categorization task of Study 3, we compared the phonetic forms found in Montreal French with those found in Montreal English. Because we had no study of Montreal English comparable to Benoît Jacques' comprehensive study of Montreal French, our analyses had to rely solely on our two small studies of Montreal French and English. These analyses should therefore be appreciated more for the nature of the analyses they propose with respect to possible language interactions than for the comprehensiveness of the data thus yielded. Again, as when trying to explain the t/d Effect, we hypothesized that categorization of stimuli presented to a subject is made with reference to a series of internal prototypes. Here, however, our internal prototypes for Montreal French were represented only by the data of the Experimenter's small study of Montreal French (Table 6); our hypothesized internal prototypes of Montreal English were represented by the data of the Experimenter's small study of Montreal English (Table 10). When a bilingual person is faced with a categorization task in one of his two languages, we furthermore assumed that both internal sets of representatives of the category in question are activated if the category in question exists in both languages. For example, since /k/ exists in Montreal French and Montreal English, a task calling for categorization of /k/ will activate the Montreal French set of representatives (kε , ki, εk, ik in Table 6) and the Montreal English set of representatives (k^{h}o , εk^{o}, ik^{o} in Table 10). The assumption was derived from findings of interference and facilitation from knowledge of another language in bilinguals when dealing with one of their languages (Weinreich, 1963). Also therefore, we expected similar phonetic prototypes for given CVs or VCs in the two languages to facilitate the phoneme categorization task and different phonetic prototypes to hinder the phoneme categorization task. On this basis, we looked for a possible net facilitatory effect for the k/g phonemic contrast in bilinguals, and a net zero effect for the p/b and t/d phonemic contrasts. These data are presented in Table 11. Table 11 shows the phonetic forms found within CVs and VCs as used in the Linguistic Categorization task of Study 3. The latter are indicated by the placement of an asterisk in the table which is presented as all phonemes possibly employed (/p/, /b/, /t/, /d/, /k/, /g/), in the two syllabic forms possibly used (CV, VC), and in all of the three vocalic contexts possibly used (ε, i, o). The phonetic forms for both Montreal French and Montreal English are presented. It can be seen from this table that for the p/b contrast, the effect is a net inhibitory one, there being only different phonetic prototypes for the appropriate CVs and VCs (actually only one instance is codable, that is [p] (Montreal French) versus [p^{h}] (Montreal English), for /p/ / ε /). For the t/d contrast also, the effect is a net inhibitory one (here two instances are codable, that is, [t$_{s}$] (Montreal French) versus [t] and [ʂ] (Montreal English), for /t/ /i/ and [t] (Montreal French) versus [t^{h}] (Montreal English), for /t/ /o/). For the k/g contrast finally, the effect is also a net inhibitory one (here again one instance only is codable, that is [k] (Montreal French) and [k^{o}] (Montreal English), for /ε/ /k/). Although these data, which would have therefore predicted a negative correlation with degree of bilingualism for all three contrasts within the Linguistic Categorization task, did not accord with our Bilingualism Effect, what was most striking about Table 11 was the great absence of phonetic exemplars for the CVs and VCs in question. There were 21 such cases for Montreal French (out of a possible total of 30) and 22 such cases for Montreal English (also out of a possible total of 30). We assumed this absence to have been due to the small nature of our studies of Montreal French and English.

In conclusion, our attempt at explaining the Bilingualism Effect within a linguistic framework for the Linguistic Categorization task proved inconclusive due to what was interpreted as an incomplete data base on the comparative phonetic forms of Montreal French versus Montreal English.

Table 10:

/p/, /b/, /t/, /d/, /k/, /g/ Stimuli: Phonetic Forms Found in Montreal English (From a Random Sampling of Words in Common Usage From an Issue of *The Gazette*)

	Syllabic Form[a]					
	CV			VC		
	Vocalic context			Vocalic context		
Phoneme	ε	i	o	ε	i	o
p	p^h	-	-	-	-	-
b	b	-	b	-	-	-
t	t^h	t, ς	t^h	-	-	-
d	-	-	d	-	-	-
k	-	-	k^h	k^o	k^o	-
g	-	-	-	-	g	-

[a] - indicates no such CVs or VCs found in this particular sample.

Table 11:

Montreal French Versus Montreal English Phonetic Forms for CVs and VCs As Used in the Linguistic Categorization Task of Study 3

	Syllabic Form[abc]											
	CV						VC					
	Vocalic context						Vocalic context					
Phoneme	ε		i		o		ε		i		o	
	Montreal French	Montreal English	Montreal French	Montreal English	Montreal French	Montreal English	Montreal French	Montreal English	Montreal French	Montreal English	Montreal French	Montreal English
p	p	*p^h				*		*		*		*
b			b	*		*b		*				*
t		*t^h	t_s	*t, ς	t	*t^h		*	t	*		*
d		*					d	*		*		*
k	k	*	k	*		*k^h	k	*k^o				*
g		*		*		*		*		*g		*

[a] * indicates a CV or VC as used in the Linguistic Categorization Task of Study 3.

[b] Montreal French forms are derived from Table 6.

[c] Montreal English forms are derived from Table 10.

STUDY 3 & STUDY 4: DISCUSSION, PART II

In Study 3 & Study 4: Discussion, Part I, we noted one set of findings confirming our hypothesis of the existence of two different mechanisms operating for the processing of speech sounds and four pieces of evidence pointing toward the possibility that the two different mechanisms at work might be dichotomized along non-linguistic/linguistic lines. Two of the latter four pieces of evidence were the subject of further analyses. They were the following. One was the finding in Study 3 that, within the Linguistic Categorization task only, the t/d contrast was performed significantly worse than both the p/b and the k/g contrasts. This was referred to thereafter as the t/d Effect. The other was the finding in Study 3 that performance only on the Linguistic Categorization task and only on the k/g contrast was significantly positively correlated with degree of bilingualism and all other Contrast by Degree of bilingualism scores were not correlated, regardless of Task. This was referred to thereafter as the Bilingualism Effect. The t/d Effect was an unexpected finding, and needed additional analyses both to remove the existence of possible artifacts giving rise to such a finding as well as to find an explanation for it within a framework which proposed a dichotomy along non-linguistic/linguistic lines for the modes of processing carried out within the Acoustic versus the Linguistic Categorization tasks. The Bilingualism Effect was an expected finding. It will be recalled that with respect to the non-linguistic/linguistic processing distinction, one of our hypotheses had been that knowledge of a second phonetic system (that is, a second language) should influence differentially phonetic versus auditory modes of processing. This is indeed what the Bilingualism Effect showed. In this case we conducted additional analyses first, again, to remove the existence of possible artifacts which might have given rise to the finding, and second, by an analysis of the two phonetic systems involved and their possible patterns of interaction within a proposed linguistic mode of operation in the Linguistic Categorization task, to explain the actual pattern of results within the Linguistic Categorization task.

With respect to the t/d Effect, we removed the existence of two possible artifacts. There was first the possibility that the different stimulus sets which comprised the Linguistic Categorization task as opposed to the Acoustic Categorization task of Study 3 might have been responsible for the differential Contrast effects obtained for each Task. This possibility was partially removed by showing, within the Linguistic Categorization task but with the Repetition data of Study 4, a replication of the t/d Effect for its two types of subset of stimuli, one which was found in both the Acoustic and Linguistic Categorization tasks of Study 3 and one which was found only in the Linguistic Categorization task. Furthermore, we later showed that the phonetic forms of the stimuli of the Acoustic Categorization task of Study 3 did not differ from those of the subset of stimuli found in both the Acoustic and Linguistic Categorization tasks but used within the Linguistic Categorization task. This removed the likelihood of a possible artifact which might have put into question the positive interpretation of the replication of the t/d Effect with the Repetition data of Study 4 for the subset of stimuli found in both the Acoustic and Linguistic Categorization tasks. This last piece of finding now strongly suggested that the relatively poor performance on t/d compared to the other two Contrasts within the Linguistic Categorization task of Study 3 was a consequence of the task involved, called linguistic categorization, and not stimulus artifacts. In both tasks, that called Acoustic Categorization and that called Linguistic Categorization, we had instructed subjects to categorize phonemically a number of consonants. However, as discussed in the Introduction to this chapter the task called Acoustic Categorization could also be accomplished by some simple form of auditory physical grouping whereas the task called Linguistic Categorization seemed to necessarily call for the notion of phonetic segments and phonemes (whether grouped productively or otherwise). In an effort to elucidate the t/d Effect within such an explanatory framework, we compared the phonetic forms of the French CVs and VCs used in Study 3 with the standard forms of Montreal French CVs and VCs, most probably commonly heard and used by our subjects. Our assumption here was that subjects would probably use such internalized standard forms when categorizing with reference to phonetic segments and phonemes. We found, both within the Acoustic Categorization task and the Linguistic Categorization task that the phonetic forms for the t/d Contrast violated the standard forms more than the phonetic forms for the other two contrasts employed. The presence of such a pattern of violations within the Linguistic Categorization task confirmed via the concurrent parallel presence of relatively poor performance on the t/d Contrast that for that task subjects were indeed categorizing phonetic segments into phonemes. The presence of such a pattern of violations within the Acoustic Categorization task confirmed via the concurrently relatively good performance on the t/d Contrast that subjects were not using for this task a mode of classification which involved categorization of phonetic segments into phonemes.

With respect to the Bilingualism Effect, we attempted to remove the existence of the following possible stimulus artifact. Again, there was the possibility that the different stimulus sets which comprised the Linguistic Categorization task as opposed to the Acoustic Categorization task of Study 3 might have been responsible for the differential pattern of correlations with Contrasts obtained for each Task. We tried to remove this possibility by attempting to find, within the Linguistic Categorization task but with the Repetition data of Study 4, a replication of the k/g low positive degree of correlation within the Linguistic Categorization task of Study 3 for its two types of subset of stimuli, one which was found in both the Acoustic and Linguistic Categorization tasks of Study 3 and one which was found only in the Linguistic Categorization task. We were unsuccessful here because the raw scores for the subset of stimuli found both in the Acoustic and Linguistic Categorization tasks of Study 3 as looked at here contained a large proportion of perfect scores. This ceiling in scores explained a resulting near-zero correlation for k/g with degree of bilingualism for this subset of stimuli. We were thus unable to remove the possibility of a stimulus artifact giving rise to the Bilingualism Effect. We next attempted to predict, within a framework calling for categorization into phonetic segments and phonemes for the task called Linguistic Categorization, and within a framework involving interactions between two such systems of categorization for bilinguals, the actual pattern of correlations for the three contrasts obtained within the Linguistic Categorization task. For the CVs and VCs used in the Linguistic Categorization task of Study 3 we compared the standard phonetic forms most probably commonly heard and used by our bilingual subjects, across the two languages involved, Montreal French and Montreal English. The use of standard forms was justified in a manner similar to that described for the t/d Effect. Furthermore, we expected overlapping forms across the two languages to facilitate categorization, and distinctive forms to hinder categorization within each CV or VC. We found that for all three Contrasts involved, such interactions should have resulted in a net hindrance of categorization for bilinguals, and consequently a negative correlation of degree of bilingualism with performance on all three contrasts. Nevertheless, our much sparser data base on standard forms here (compared to the data base used for the explanation of the t/d Effect) led us to view with caution the results thereby postulated to hold. The mode of exploring possible interactions across linguistic systems, however, seemed to be potentially fruitful.

CHAPTER 5

General Discussion

REVIEW OF FINDINGS

The major questions addressed by this thesis were whether speech could be processed in two different ways, and whether these two different processes could be classified as "acoustic" versus "linguistic". Studies 1 and 2 represented our first attempts at answering these questions. Within the paradigm employed for Study 1, the expected evidence in support of the two questions was partly merged. In particular, we expected the pattern of development for performance on native versus foreign speech contrasts to be analogous to the development of processing of upright versus inverted faces between the ages of four to eighteen; this would indicate both the existence of two separate processes in speech processing and an auditory versus a phonetic distinction between modes of speech processing. One line of analysis found no different pattern of development for native versus foreign speech contrasts, the other line of analysis found some similarity with the upright versus inverted face findings, namely, a linear and quadratic trend for native contrasts and a linear trend only for the development of performance on foreign contrasts. Nevertheless, this difference in pattern here could likely be dismissed since the quadratic component may have been due to a ceiling effect. Possibly additional evidence with respect to the auditory/phonetic distinction, was twofold; we expected no difference between males and females in the development of performance on the foreign contrast (indicative of an auditory mode of processing). In fact, no difference was found. Also, we expected a lag for males compared to females in the expected improvement in development of performance on native contrasts (indicative of the shift from auditory to phonetic processing). In fact, no sex differences were found in the development of performance on native contrasts. An additional analysis performed gave quite puzzling results: on the theory that a high positive correlation indicated processing based on similar, physical cues (that is, auditory processing) and a low or zero correlation indicated processing based on different bases (that is, phonetic processing), correlations between performance on the native Voicing contrast and the foreign Duration contrast (both cued physically by durational cues) were performed. For females, these correlations were unexpectedly high positive at both ages 6 - 8 and 10 - 12, for males, these correlations were unexpectedly high positive at age 6 - 8 then low at age 10 - 12. The exact opposite set of findings by sex would have been expected on the basis of the literature on the earlier development of linguistic abilities of females versus males. Although the findings of Study 1 proved inconclusive with respect to both questions, they were the first step in our approach toward exploring new avenues for the elucidation of the auditory/phonetic processing distinction. Especially problematic with this Study was the post-hoc realization that the foreign contrast employed could also have been interpreted as a native suprasegmental contrast. Study 2 attempted to refine upon the previous study. Within the paradigm employed for Study 2, the evidence in support of the two questions was as follows. It will be recalled that subjects heard pairs of VCVs (called consonants embedded in speech) or 'C's (called consonants spliced out of speech) in which the consonants were either a pair of stops or a pair of fricatives. Subjects had to judge the relative loudness or pitch of the consonants. With respect to the question as to whether speech could be processed in two different ways, we expected first to replicate Dorman's (Dorman, 1974) exact findings on loudness judgments in adults using stop consonants. Indeed, like Dorman, we found that loudness judgments for stops spliced out of speech was significantly superior to loudness judgments for stops embedded in speech, which was performed poorly. Next, we expected to find a significant difference in the pattern of development for loudness judgments in stops spliced out of speech compared to stops embedded in speech. Here, our findings were not according to expectation as no such difference in pattern of development was found. We may thus say that we have some evidence here confirming previous evidence for the existence of two separate processes in speech processing. To be able to say that the two processes involved are auditory versus linguistic, we expected four pieces of evidence. We first expected to replicate

Dorman's (Dorman, 1974) exact findings with stop consonants in adults, but with pitch judgments rather than loudness judgments. The pattern found was exactly opposite to that predicted: pitch judgments in adults for stops embedded in speech were significantly better than pitch judgments for stops spliced out of speech. Next, we expected that in adults loudness judgments for fricatives in speech (which are apparently less encoded linguistically than stop consonants) should exhibit a phonetic pattern intermediate to the one found to exist for stop consonants versus vowels (which are apparently not encoded linguistically). For vowels, Dorman had found no significant difference between loudness judgments depending on whether they were embedded in a speech context or spliced out of speech, both being performed very well. Here we expected loudness judgments for fricatives within speech to be performed midway between chance and perfect levels. In fact, loudness judgments for fricatives within speech were performed midway between chance and zero level performance. This was much more poorly than similar judgments for stops in speech which were close to the expected chance levels. This was again not as predicted. Performance on loudness judgments for fricatives extracted from speech was as expected found to be perfect, just as for stop consonants. Third, we expected both males and females to perform equally well across all three age groups studied (ages 6, 10 and 18 - 19) for loudness judgments in stop consonants spliced out of speech (this was an index of an auditory form of processing). This was indeed found to be the case. Finally, we expected both males and females to exhibit a decrement in performance from perfect to chance levels for loudness judgments in stop consonants embedded in speech (this was an index of a phonetic form of processing), the decrement occurring between the ages of 6 to 10 for females, and between the ages of 10 to 18 - 19 for males. In fact no such decrement was found, performance being uniformly poor across the three age groups, for both sexes. In summary then, only part of one line of evidence, that with respect to the pattern of development in both males and females for what was assumed to be an auditory process, conformed to our predictions with respect to the auditory/phonetic nature of the distinction between the two processes. There was a problem with this study which might have artefactually produced the unexpected findings with respect to loudness judgments in adults for fricatives embedded in speech: this may have been due to poor stimulus construction in this case. However, there were also more fundamental problems associated with this study which led us to refine our paradigm even further. These had to do with the validity of the assumptions which governed the criteria on which the dependent variable was measured. We decided for our next and final attempt at answering the experimental questions to run a series of studies in which the tasks were freer of assumptions which were difficult to justify. We also added, for this next series of studies, Study 3 and Study 4, another variable in our exploration of the validity of the auditory/phonetic processing distinction, that of degree of second language ability. It will be recalled that subjects had to perform within one of two situations, one called Acoustic Categorization, the other called Linguistic Categorization. The stimuli for Acoustic Categorization were sets of eight CVs or VCs with one point of change in the phoneme consonant and no change in vowel. The stimuli for Linguistic Categorization were sets of eight alternating CVs and VCs with one point of change in the phoneme consonant. Three sets of consonantal phonemic contrasts were employed: p/b, t/d and k/g. Within Study 3, subjects had to press a button at the moment the consonant phoneme changed, whether for Acoustic Categorization or Linguistic Categorization; these same subjects had to repeat and write down all stimuli heard for Linguistic Categorization within Study 4. With respect to whether speech could be processed in two different ways, we expected that in Study 3 there would be a significant difference in the pattern of development for performance on Acoustic Categorization compared to Linguistic Categorization. This was indeed found to be the case for females and thus again supports a hypothesis of the existence of two different mechanisms operating for the processing of speech sounds. With respect to the nature of the different processes that are at work, we expected and found the following. We hypothesized that, for both males and females, Acoustic Categorization in Study 3 should be performed close to perfectly, for all three age groups investigated (ages 7, 11 and 17). For Linguistic Categorization in Study 3 and Study 4, it was hypothesized that, for females, performance should be close to chance levels at age 7, and close to perfect levels at ages 11 and 17, whereas for males performance should be close to chance levels at ages 7 and 11, and close to perfect levels at age 17. Contrary to expectations, the Acoustic Categorization task of Study 3 did exhibit a developmental trend across the three age groups observed with the improvement in performance occurring between the ages of 11 and 17. The pattern of development of Linguistic Categorization was only partly according to expectation: the pattern was repeated across Study 3 and Study 4 and will be described below. As expected, with regard to sex differences in presumed acoustic versus linguistic modes of categorization, both males and females developed similarly for Acoustic Categorization in Study 3. Within Linguistic Categorization for both Study 3 and Study 4, again as expected, there were marked differences in the mode of development of males versus females. In fact, females exhibited no development in their performance on Linguistic Categorization, performing well throughout. Males did show a significant improvement somewhere after age 7: they were, as predicted inferior to females in their performance, although at age 7 rather than at age 11, with a performance close to chance levels; an unexpected superiority of males over females at age 17 was present in Study 3, but was not found again in Study 4. Two sets of findings then, up to now, partly confirm our expectations with regard to the processing dichotomy being along non-linguistic/linguistic lines. It is the actual pattern of development for Linguistic Categorization (presumably reflecting linguistic processing) in males repeated across three response modes, and it is the pattern of developmental similarity (for Acoustic Categorization (presumably reflecting non-linguistic processing)) and difference (for Linguistic Categorization, repeated across three response modes) found between males and females. The third set of findings expected was the following. It was expected that bilingualism should affect differentially performance on non-linguistic versus linguistic tasks. On that basis, within Study 3, pooling across the age and sex of subjects, it was expected that linear regressions between degree of bilingualism and performance on the three sets of phonemic contrasts employed should be different within the Acoustic Categorization task compared to within the Linguistic Categorization task. This was indeed found to be the case. In fact, performance only on the Linguistic Categorization task and only on the k/g contrast was significantly positively correlated with degree of bilingualism and all other Contrast by degree of bilingualism scores were not correlated, regardless of task. Study 3 and Study 4 therefore seemed to provide both evidence for the existence of two separate processes in speech processing and evidence that the two separate processes could be classified as non-linguistic versus linguistic ones. One additional unexpected finding, when subjected to further investigation, added another piece of evidence favoring the dichotomization of speech processing along non-linguistic/linguistic lines. It was the finding that, in Study 3, within the Linguistic Categorization task only, the t/d contrast was performed significantly worse than both the p/b and k/g contrasts. (Within the Acoustic Categorization task, the t/d contrast was performed as well or significantly better than the other two contrasts). Further analyses showed this effect not to be attributable to possible differences in stimuli between the two tasks. A comparison of the phonetic forms of the French phonemes found in Study 3 with the standard phonetic forms of the phonemes, derived from two studies of Montreal French, and most probably heard and used by our subjects, revealed for Study 3 within both stimuli used for Acoustic Categorization and for Linguistic Categorization more severe violations of standard Montreal French for the t/d phonemic contrast than for the other two contrasts. The presence of such a pattern of violations within the Linguistic Categorization task confirmed via the concurrent parallel presence of relatively poor performance on the t/d Contrast that for that task subjects were indeed categorizing phonetic segments into phonemes (a linguistic process). The presence of such a pattern of violations within the Acoustic Categorization task confirmed via the concurrently relatively good performance on the t/d Contrast that subjects were not using for this task a mode of classification which involved categorization of phonetic segments into phonemes (not a linguistic process).

It may then be said, based on the findings of Study 2 and Study 3, that we have good evidence to suggest that speech can be processed in at least two different ways. On the basis of Study 3 and Study 4 we have, furthermore, good evidence to suggest that one of the forms of this dichotomy in processes is along non-linguistic/linguistic lines. External replication of Study 3 and Study 4 would further strengthen such a conclusion. In addition, such a replication would probably benefit from a refinement in the method of measuring degree of bilingualism. Although the pattern of correlations between degree of bilingualism and performance on contrasts within the Acoustic Categorization task compared to within the Linguistic Categorization task were in the predicted direction, there are some questions about this finding. First the only positive correlation obtained was relatively small. Next, an attempt to explain the pattern of correlations actually obtained within the Linguistic Categorization task within a framework calling for a linguistic mode of functioning within that task and within a framework calling for specific influences across linguistic systems within such a mode of functioning, proved unsuccessful. One possibility to justify this lack of success is that the data base of standard Montreal French and standard

Montreal English used to explain the pattern of correlations was incomplete. Another possibility is that our measure of degree of bilingualism was not sufficiently oriented to productive aspects of the language, which seem to be essential components of the linguistic mode as tested within this thesis and as discussed in the GENERAL INTRODUCTION. A replication, then, of Study 3 and Study 4, should take these facts into account.

IMPLICATIONS OF FINDINGS

Experiments on the Phonetic Mode

Study 3 and Study 4 have combined two aspects of the research that has been conducted to muster support for the existence of a phonetic mode: through what we have called Acoustic Categorization in Study 3, we have touched upon a series of psychological studies on speech sounds and the Phonetic Mode, namely the studies on categorical perception; through what we have called Linguistic Categorization in Study 3 and Study 4, we have touched upon a series of studies on the physical characteristics of speech sounds and the Phonetic Mode, namely the studies of Liberman et al. (1967) on the spectrographic profile of stop consonants.

As has been mentioned in the Introduction to Chapter 4, in Study 3, under what was called Acoustic Categorization, subjects were confronted with sets of stimuli that could, on the basis of a spectrographic characterization of speech sounds, be categorized rather simply. A similar process of physical categorization seemed to be involved within the classical categorical perception paradigm, and yet subjects were there unable to discriminate between members of a given phonetic category. This was taken to reflect a phonetic mode of processing. Pisoni and Lazarus (1974) showed that discrimination could be markedly improved if the paradigm was changed from one requiring encoding of previous stimuli to one requiring judgment based on magnitude differences between pairs of stimuli. What we have called Acoustic Categorization within Study 3 resembles the modification used by Pisoni and Lazarus (1974) to go from a categorical mode of perception (a phonetic mode) to a more continuous mode of perception (an auditory mode): judgment can be based on magnitude differences between pairs of stimuli. Our subsequent findings, also, support the notion of an auditory mode for speech stimuli thus grouped.

Also as mentioned in the Introduction to Chapter 4, in Study 3 and Study 4, under what was called Linguistic Categorization, subjects were confronted with sets of stimuli that could not, on the basis of a spectrographic characterization of speech sounds, be categorized rather simply. This finding with stop consonants in varying position in the syllable and with varying vocalic contexts had been used by Liberman et al. (1967) to favor the existence of a phonetic mode for the capacity to perceive a psychologically invariant speech sound in the presence of a variable physical signal. The presentation otherwise of our stimuli in a manner analogous to that used for what was called Acoustic Categorization in Study 3 again permitted grouping to be performed on the basis of magnitude differences between pairs of stimuli if such a mode of grouping did indeed apply to the consonants so placed. We came to the conclusion that the mode of grouping utilized here was more specifically "linguistic". In that sense, our findings support the above mentioned claims of Liberman et al. (1967).

Experiments on Language Pathologies and the Phonetic Mode

Among the children classified as "learning-disabled", who are characterized by a significant deficit in educational achievement in the apparent absence of a general intellectual deficit, a primary behavior disorder, an uncorrected sensory handicap, or a history of environmental deprivation (Doehring, personal communication; Lahey & Kazdin, 1979), some present themselves with reading and spelling difficulties. It is our hypothesis that the task presumed to tap a linguistic mode of categorization, which we have referred to as Linguistic Categorization within Study 3 and Study 4, may underlie some of these reading and spelling difficulties. It is also our hypothesis that the task presumed to tap a non-linguistic mode of categorization, which we have referred to as Acoustic Categorization within Study 3 may be performed well by such children. These two hypotheses, which bear further investigation, are supported by the clinical observation that in these children reading and spelling difficulties often become most apparent when faced with material which most evidently requires having the ability to categorize according to phonetic segments and phonemes, that is, material which is unfamiliar. In such a situation, the nature of the approach to the material seems to point to an inability to use the categories of phonetic segments and phonemes, but instead, the ability to use some simpler form of auditory grouping. Specifically, a subject with reading and spelling difficulties may produce, for a given word, a correct partial response followed by a clearly aberrant finishing portion (e.g. read "famous" as "father"), whereas a subject with no reading and spelling difficulties may produce a painfully elaborated response with slight phonetic or phonemic irregularities here and there (e.g. read "famous" as "f-æ-m-o-ɷ-s"). The study in the children with reading and spelling difficulties of what appears to be non-linguistic versus linguistic processing through Acoustic Categorization versus Linguistic Categorization as presented in Study 3 and Study 4 may prove useful by possibly helping the early prediction of future school difficulties and by increasing our understanding of some learning disabilities.

Experiments on Language

One of the most direct pieces of evidence in favor of dichotomizing the processing of speech sounds into non-linguistic versus linguistic modes was finding, through a comparison of the phonetic forms of the Montreal French phonemes /p/,/b/, /t/, /d/, /k/, /g/ with those used in Study 3, relatively more violations within Study 3 for the phonetic forms of the t/d contrast than of the other two contrasts compared to the standard phonetic forms most probably heard and used by our subjects. Because the pattern of violations paralleled the pattern of performance on the three sets of contrasts within the Linguistic Categorization task we were able to argue that that task did indeed involve a process of categorization into phonetic segments and phonemes, and thus a linguistic process. Because the pattern of violations did not parallel the pattern of performance on the three sets of contrasts within the Acoustic Categorization task we were able to argue that that task did not involve a process of categorization into phonetic segments and phonemes, and thus not a linguistic process. This finding stresses the importance of extensive control not only of all possible languages used by the subjects or in the experiment, but of finer distinctions of form across different dialects of a given language used by the subjects or by the experiment. The issue is especially relevant in a multilingual setting such as Montreal.

CONTRIBUTION TO ORIGINAL KNOWLEDGE

We devised within this thesis three sets of tasks which presumably tapped in different ways non-linguistic versus linguistic processes in speech processing. A first dichotomization into two separate processes in speech processing was attempted mainly through finding differential patterns of development in the performance of those aspects of the tasks which presumably tapped non-linguistic versus linguistic processes. The use of that variable in the study of such a dichotomy, is novel. It confirmed our predictions most clearly in the third task (that of Study 3 and Study 4). On the basis of the analogy that we drew between development of simple versus complex stimuli and development of non-linguistic versus linguistic processes with respect to speech, between the differences across sexes in the development of non-linguistic versus linguistic tasks and the differences across sexes in the development of non-linguistic versus linguistic processes with respect to speech, and between specific patterns of interactions across linguistic systems and differential patterns of interactions with respect to non-linguistic versus linguistic processes in speech processing in bilinguals, we then looked at performance on the three sets of tasks mainly by taking each time into consideration the above three sets of variables. The use of these three sets of variables in the study of the validity of a phonetic mode, distinct from an auditory mode, in speech processing, is novel. It furthermore proved enlightening. This was especially true for the third task attempted (that of Study 3 and Study 4) where we were able to show expected differences in development, partially, expected differences in development across sexes, clearly, and expected differences in bilinguals, though further work seems to be needed here, for presumed non-linguistic versus linguistic processes in speech. In Study 3 and Study 4 we also found, through a careful comparison between phonetic forms in standard Montreal French and phonetic forms in French as used in these studies what appears to be another piece of original evidence favoring the validity of a phonetic mode distinct from an auditory mode. Our tasks progressively focused on aspects of the auditory/phonetic processing distinction which were most debated upon in the current literature: this is best seen again in our final task (that of Study 3 and Study 4) in which we touch upon the auditory/phonetic processing distinction as it is debated upon in the categorical perception literature and as it is debated upon in the literature on the physical descriptions that are most accurate for speech sounds. Whereas our findings here, with respect to categorical perception, seem to support other findings advocating at least partly a non-linguistic explanation for this phenomenon, with respect to the physical characteristics of speech sounds and the phonetic mode, they support some of the findings and conclusions of Liberman et al. (1967). Our findings, then, especially for Study 3 and Study 4, enlightened us with respect to the dichotomization of speech processing into non-linguistic versus linguistic modes in novel ways, but also in ways which had implications for current research addressing that issue.

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APPENDIX 1

Study 1: Linguistic Criteria for Subject Inclusion in Study

a. AGES 4 - 6, 6 - 8.

Experimenter asked each child the following questions, in English:

1. What is the colour of your sweater?
2. Do you like playing outside with your friends?
3. Do you have any brothers or sisters?

Capacity to respond to a minimum of two out of three questions was considered as evidence for English comprehension, and as a criterion for exclusion from the sample.

b. AGES 10 - 12

Each child had to fill out the Modified and Adapted Vaid Questionnaire below.

QUESTIONNAIRE VAID MODIFIÉ ET ADAPTÉ
(Used by permission)

Les questions qui vont suivre portent surtout sur toi et tes langues. Les réponses que tu nous donneras sont importantes pour notre recherche, alors essaie de le compléter avec soin. Réponds à chaque question au meilleur de tes connaissances.

1. Nom: ______________________________
2. Sexe: ______________________________
3. Date de naissance: ______________ ______________
4. École ou collège: ______________________________
5. Année d'études: primaire __________ (donne l'année exacte)
   secondaire __________ (donne l'année exacte)
6. Dans quel pays es-tu né? ______________________________
7. Quelle est ta langue maternelle (la langue que tu as apprise en premier)? ______________
8. Si tu connais d'autres langues que ta langue maternelle, à quel âge les as-tu apprises?
   0 à 3 ans ______________ (donne la langue)
   3 à 7 ans ______________ (donne la langue)
   10 ans et plus ______________ (donne la langue)

9. Décris comment tu as appris tes secondes langues. Décris pour chaque langue:
   a) à la maison (écris la langue que tu as apprise ainsi) ____________________
   ____

   b) à l'école, dans un camp d'été ou autre (donne des détails et la langue)____________
   ____

   c) dans un autre pays ou une autre province (donne des détails et la langue)__________
   ____

   d) autre (précise ce que tu veux dire et la langue) ____________________
   ____

10. Tes secondes langues, les as-tu apprises
    a) à l'école, dans un cours ____________ (coche si oui et écris quelle langue)
    b) avec des copains, dans la rue ____________ (coche si oui et écris quelle langue)

    aussi les as-tu apprises
    c) surtout en parlant et en écoutant ____________ (coche si oui et écris quelle langue)
    d) surtout en lisant et en écrivant ____________ (coche si oui et écris quelle langue)

11. Je veux savoir à quel point tu connais *toutes* ces langues du point de vue de l'écriture, comment tu les parles, les lis et les comprends. Tu donneras des numéros au lieu de dire "très bien", "mal", etc. Voici à quoi correspondent les numéros:

    1 = presque pas
    2 = très mal
    3 = mal
    4 = comme ci, comme ça
    5 = bien
    6 = très bien
    7 = parfaitement

    (N'oublie pas de donner à chaque langue, *quatre* chiffres en tout)

	La langue	écrite	parlée	lue	comprise
1.					
2.					
3					
4.					

12. Je veux aussi savoir combien tu utilises chaque langue en général (c'est-à-dire si tu la parles souvent, ou la lis souvent, ou l'écris souvent ou pas). De nouveau, tu me donneras des numéros pour m'indiquer si c'est souvent ou pas. Utilise les chiffres suivants:

    1 = presque pas
    2 = très peu
    3 = peu
    4 = de temps en temps
    5 = souvent
    6 = très souvent
    7 = presque tout le temps

    (N'oublie pas de me donner chacune de tes langues)

	La langue	Le chiffre qui indique la fréquence
1.		
2.		
3.		
4.		

13. Est-ce qu'il y a des langues que tu connaissais mieux comme enfant qu'à présent? Laquelle (ou lesquelles)? ______________________________

14. Quelles langues parlent tes parents?
ta mère ______________________________
ton père ______________________________

15. Dans quelles langues parles-tu avec:
ta mère ______________________________
ton père ______________________________
tes frères et soeurs ______________________________
tes amis ______________________________
toi-même ______________________________
d'autres personnes ______________________________

16. Lorsque tu parles de choses sur ta famille, quelles langues utilises-tu? ______________________________

Lorsque tu parles de choses sociales (sorties, amis, sports), quelles langues utilises-tu? ______________________________

Lorsque tu parles de sujets d'école (devoirs, examens) quelles langues utilises-tu? ______________________________

Because complete unilingualism is quasi impossible to find in these areas, subjects were divided into three samples (samples I, II, III, with I representing the most unilingual group, and III the least unilingual group) on the basis of answers to questions 7, 8, 12, 15, 16, 17. The criteria for assignment to each sample were the following:

Answers on Modified and Adapted Vaid Questionnaire:

SAMPLE I	Q.7	-	French
	Q.8	-	7 - 10 years or more
	Q.12	-	$\leqslant 2$ for second languages and $\geqslant 6$ for mother tongue.
	Q.15	-	All French *or* All French for family members *and* French + other for one of rest.
	Q.16	-	All French
SAMPLE II	Q.7	-	French
	Q.8	-	3 - 7 years or more
	Q.12	-	$\leqslant 3$ for second languages and $\geqslant 6$ for mother tongue
	Q.15	-	All French + 1 other with other than family member
	Q.16	-	All French + 1 other
SAMPLE III	Q.7	-	French
	Q.8	-	0 to 3 years or later
	Q.12	-	$\leqslant 5$ for second languages and $\geqslant 6$ for mother tongue
	Q.15	-	All French plus 2 others with other than family
	Q.16	-	All French plus 2 others

Subjects were then selected at random, first from Sample I, then when that was exhausted, from Sample II, and so forth. Finally, out of all subjects selected, 8 came from Sample I (3 males, 5 females), 13 came from Sample II (6 males, 7 females), 3 came from Sample III (3 males, no females).

c. AGE 16 - 18

Each subject had to fill out the Modified Vaid Questionnaire below.

QUESTIONNAIRE VAID MODIFIE
(Used by permission)

Ce questionnaire porte tout particulièrement sur votre passé linguistique. C'est un questionnaire important pour notre recherche; nous vous prions donc de le compléter avec soin. Répondez à chaque question au meilleur de votre connaissance.

1. Nom: ____________________

2. Sexe: M F (Encerclez la réponse appropriée)

3. Date de naissance: ________ (jour) ________ (mois) ________ (année)

4. École ou collège: ____________________

5. Année d'études: secondaire ____________ (l'année)
CEGEP ____________ (l'année)

6. Dans quel pays êtes-vous né(e)? ____________

7. Quelle est votre langue maternelle (la langue que vous avez apprise en premier)? ____________

8. Si vous connaissez d'autres langues que votre langue maternelle, à quel âge l'avez (les avez) vous apprise(s)?

Langue

0 à trois ans ____________
3 à 7 ans ____________
10 ans et plus ____________

9. Décrivez le contexte dans lequel vous avez appris votre (vos) seconde(s) langue(s). Décrivez pour chaque langue.

a. Même contexte que ma première langue - à la maison.
Spécifiez ____________

b. Contexte social différent (par exemple école, club).
Spécifiez ____________

c. Différent pays ou milieu culturel.
Spécifiez ____________

d. Autre. Spécifiez ____________

10. Votre (vos) seconde(s) langue(s), l'avez-vous (les avez-vous) apprise(s), d'une façon
a. formelle ____________ ou, b. informelle ____________
c. surtout en parlant et en écoutant ____________ ou
d. surtout en lisant et en écrivant ____________

11. Quel est votre degré de connaissance de chacune de vos langues? Utilisez l'échelle suivante:

1 = presque nul
2 = très bas
3 = bas
4 = moyen
5 = bon
6 = très bon
7 = excellent

	La langue	écrite	parlée	lue	comprise
1.					
2.					
3					
4.					

12. Sur votre usage global de langage à l'intérieur d'une semaine (conversation, lecture, écriture) indiquez les pourcentages relatifs utilisés pour chacune de vos langues.

	Langue	% utilisée
1.		
2.		
3		
4.		

13. Est-ce qu'il y a une langue (ou des langues) que vous connaissiez mieux (compreniez/parliez) comme enfant que maintenant?
Précisez ____________________

14. Quelle(s) langue(s) parlent vos parents?
Votre mère: ____________________
Votre père: ____________________

15. Quelle(s) langue(s) utilisez-vous pour parler avec:
Votre mère: ____________________
Votre père: ____________________
Vos frères et soeurs: ____________________
Vos amis: ____________________
Vous-même: ____________________
d'autres (précisez la relation): ____________________

16. Lorsque vous discutez les sujets suivants quelle(s) langue(s) avez-vous tendance à employer?

Sujet	Langues
De famille	
Social	
Académique	
Commercial	
Autre/précisez	

Again, because of difficulty in finding completely unilingual subjects in these areas, subjects were divided into three samples (Sample I, II, III, I being the most unilingual, III the least) on the basis of answers to questions 7, 8, 12, 15, 16, 17. The criteria for assignment to each sample were the following:

Answers on Modified and Adapted Vaid Questionnaire:

SAMPLE I Q.8 - 10 years and more
Q.12 - < 30% in toto for second languages
Q.15 - All French
or All French for family members and French + other for one of rest
Q. 16 - All French

SAMPLE II Q.8 - 3 to 7 years
Q.12 - ⩽ 40% in toto for second languages
Q.15 - All French + 1 other with other than family members
Q.16 - All French + ⩽ 2 others except for: in family, social, academic

SAMPLE III Q.8 - 0 - 3 years or later
Q.12 - ≤ 40% in toto for second languages
Q.15 - same as for Sample II
Q.16 - same as for Sample II

Subjects were then selected at random, first from Sample I, then when that was exhauted, from Sample II, and so forth. Finally, out of all subjects selected, all came from Sample I.

Each subject was scored on the Harris and Palmer English language comprehension test as it appears below (McGraw-Hill, Inc.) (Used by permission). The test involves listening to a tape and responding to multiple choice questions. There are three parts: a) Answering questions, b) Understanding statements, c) Comprehending dialogues, as can be seen below.

GENERAL DIRECTIONS

1. This is a test of your ability to comprehend spoken English. It is in three parts, and there are special directions for each part.
2. Mark only *one answer* for each problem. If you change your mind about an answer after you have marked it on the answer sheet, completely erase your first answer and then mark your new answer.
3. Try to answer every problem. If you are not sure of the correct answer, make the best guess that you can. Your score on the test will be based on the number of correct answers that you give.
4. Do not make any marks in this test book. You must put *all* your answers on the separate answer sheet which you have been given.
5. Be sure that you have printed your name, today's date, your native language, and your country in the spaces provided for them at the top of the answer sheet.

Part I: Answering Questions

Directions: In this part of the test you will hear 20 questions. Each question will be spoken *just one time*, and it will *not* be written out for you. Therefore, you must listen very carefully. After you hear a question, read the four possible answers that are printed in this test book and decide which one would make the *best answer* to the question you have heard. Then find the number of the problem on your answer sheet and mark your answer by putting an x in the space over the letter A, B, C, or D - whichever goes with the answer you have chosen.

Listen to the following example.

You will hear: "When are you going to New York?"
You will read: (A) To visit my brother
(B) By plane
(C) Next Friday
(D) Yes, I am

The best answer to the question "When are you going to New York?" is choice (C), *Next Friday*. Therefore, if this problem were in the test, you would find the number of the problem on your answer sheet and mark choice (C) as shown below.

( ) ( ) (x) ( )
A B C D

This is the way you should answer all the problems in Part I.

Now let us begin the test with question number 1.

1. (A) Yes, I do.
   (B) About twenty minutes.
   (C) Take a Number 30.
   (D) Yes, you should

2. (A) Yes, I will.
   (B) Just $50.
   (C) Yes, I have to.
   (D) Just two days.

3. (A) I believe he does.
   (B) I think it's a drugstore.
   (C) Yes, it's his own.
   (D) Yes, he's very kind.

4. (A) Since last April.
   (B) Yes, I do.
   (C) At the new Hilton Hotel.
   (D) Until the end of this month.

5. (A) About noon.
   (B) By bus.
   (C) To the baseball game.
   (D) Certainly we should.

6. (A) Until about ten o'clock.
   (B) Yes, I usually do.
   (C) At my brother's house.
   (D) Yes, in the evening.

7. (A) Yes, I see her.
   (B) They're very nice.
   (C) Yes, I see them.
   (D) Whenever they come to Washington.

8. (A) Yes, I often used to.
   (B) It was Mary's.
   (C) Yes, I took them.
   (D) I'm quite used to it now.

9. (A) Yes, I always do.
   (B) In the library.
   (C) Right after dinner.
   (D) Yes, I did.

10. (A) At the new department store.
    (B) No more than $30.
    (C) As soon as you can.
    (D) Yes, I think you should.

11. (A) I'll be glad to.
    (B) Yes, he did.
    (C) At about four o'clock.
    (D) No, he hasn't.

12. (A) Yes, I do.
    (B) Next fall, I believe.
    (C) Yes, she does.
    (D) It's an excellent idea.

13. (A) It's hanging in the hall.
    (B) Yes, it's tonight.
    (C) At about eight o'clock.
    (D) Yes, I think you should.

14. (A) Yes, he does.
    (B) In two days.
    (C) Since 1964.
    (D) By plane.

15. (A) Yes, it will be the last one.
    (B) At eight o'clock.
    (C) No more than two hours.
    (D) Yes, it begins in an hour.

16. (A) I've just met him once.
    (B) Yes, he's quite well now.
    (C) I've known her for years.
    (D) Yes, I certainly do.

17. (A) Yes, on the hall table.
    (B) No, I don't know when he left.
    (C) No, I don't know where he is.
    (D) Yes, I know he did.

18. (A) Yes, Mary has two sisters.
    (B) No, one is a teacher.
    (C) Yes, Mary has two nurses.
    (D) No, Mary is a secretary.

19. (A) No, he isn't here just now.
    (B) About once a month.
    (C) Very little, really.
    (D) Yes, I can hear him.

20. (A) Yes, she likes him very much.
    (B) He's a very amusing man.
    (C) Yes, George likes her very much.
    (D) She's a very charming woman.

Part II: Understanding Statements

Directions: In this part of the test you will hear 20 statements. Each statement will be spoken *just one time*, and it will *not* be written out for you. After you hear a statement, read the four sentences that are printed in this test book and decide which one is *closest in meaning* to the statement you have heard. Then find the number of the problem on your answer sheet and mark your answer by putting an x in the space over the letter A, B, C, or D - whichever goes with the sentence your have chosen.

Listen to the following example.

You will hear: "George has just returned home from his vacation".
You will read: (A) George is spending his vacation at home.
(B) George has just finished his vacation.
(C) George is just about to begin his vacation.
(D) George has decided not to take a vacation.

Choice (B), *George has just finished his vacation*, is closest in meaning to the statement you heard, "George has just returned home from his vacation". Therefore, choice (B) is the answer to this problem and you would mark your answer sheet as shown below.

( ) (x) ( ) ( )
A B C D

This is the way you should answer all the problems in Part II.

Now let us begin Part II with problem number 21.

21. (A) Jim likes neither tea nor coffee.
(B) Jim likes tea better than coffee.
(C) Jim likes coffee just as much as tea.
(D) Jim likes coffee better than tea.

22. (A) Paul came to visit us.
(B) Paul sent us a letter.
(C) Paul attempted to call us.
(D) Paul wanted to help us.

23. (A) We had trouble finding Carl's letter.
(B) Carl had trouble reading the letter.
(C) We had trouble reading Carl's letter.
(D) Carl had trouble finding the letter.

24. (A) I think George is a poor driver.
(B) I've never seen George drive.
(C) I think Helen is a poor driver.
(D) I've never seen Helen drive.

25. (A) We couldn't find John's homework.
(B) The homework was difficult for John.
(C) We couldn't understand John's homework.
(D) John thought the homework was easy.

26. (A) Mary has found the children.
(B) Mary raised the children herself.
(C) Mary likes the children very much.
(D) Mary is playing with the children.

27. (A) We saw Harry although he was late.
(B) We saw Harry although we were late.
(C) We didn't see Harry because he was late.
(D) We were too late to see Harry.

28. (A) Bob will be here but Betty won't.
(B) Neither Bob nor Betty can come.
(C) Betty will be here but Bob won't.
(D) Both Betty and Bob can come.

29. (A) There were 50 people in the theater.
(B) There were 75 people in the theater.
(C) There were 100 people in the theater.
(D) There were 150 people in the theater.

30. (A) We were sorry that Ruth didn't attend the party.
(B) Neither Ruth nor we attended the party.
(C) We enjoyed attending the party with Ruth.
(D) Ruth enjoyed the party more than we did.

31. (A) The Smiths left at eleven thirty (11:30).
(B) The Smiths left at twelve o'clock (12:00).
(C) The Smiths left at twelve thirty (12:30).
(D) The Smiths left at one o'clock (1:00).

32. (A) Alice wants the box.
(B) Alice wants the suit.
(C) Alice wants the hat.
(D) Alice wants the case.

33. (A) There probably are six eggs left.
(B) There probably are eight eggs left.
(C) There probably are ten eggs left.

34. (A) Mary didn't believe what John said.
(B) Mary believed what I told John.
(C) Mary didn't believe what I told John.
(D) Mary believed what John said.

35. (A) We took the train and it was late.
(B) We took the bus and it was on time.
(C) We took the train and it was on time.
(D) We took the bus and it was late.

36. (A) We had just seen a movie when we met Helen.
(B) Helen was going to a movie when we met her.
(C) Helen had just seen a movie when we met her.
(D) We were going to a movie when we met Helen.

37. (A) Jane and Ann are very different.
(B) Jane doesn't like her sister.
(C) Jane and her sister are alike.
(D) Jane doesn't like Ann's sister.

38. (A) Only Jack's first attempt was successful.
(B) Only Jack's second attempt was successful.
(C) Both of Jack's attempts were successful.
(D) Neither of Jack's attempts was successful.

39. (A) Paul likes living here very much now.
(B) Paul hasn't become accustomed to our climate yet.
(C) Paul used to like living here, but he doesn't anymore.
(D) Paul is accustomed to our climate now.

40. (A) We haven't known her long, and neither has Bill.
(B) We've known her longer than Bill has.
(C) Bill has known her longer than he's known us.
(D) Bill has known her longer than we have.

Part III: Comprehending Dialogues

Directions: In this part of the test you will hear 10 short conversations between a man and a woman. You will hear each conversation *just one time*, and it will *not* be written out for you. At the end of each conversation, a third voice will ask a question about what was said. After you hear a conversation and the question about it, read the four possible answers that are printed in this test book and decide which one is the *best answer* to the question you were asked. Then find the number of the problem on your answer sheet and put an x in the space over the letter A, B, C, or D - whichever goes with the answer you have chosen.

Listen to the following example.

You will hear: (man) "Are you still planning to leave for New York next Monday?"

(woman) "I'm afraid not. My husband just found out he'll be in a meeting until late that afternoon, so we won't be able to get started until the following morning."

(3rd voice) On what day does the woman expect to leave for New York?

You will read: (A) Sunday
(B) Monday
(C) Tuesday
(D) Wednesday

From the conversation we learn that the woman and her husband cannot leave on Monday, but will have to wait until the following morning, which would be Tuesday. Therefore, the correct answer to the question is choice (C), which you would mark on your answer sheet after the number of the problem.

( ) ( ) (x) ( )
A B C D

Now let us begin Part III with problem number 41.

41. (A) He liked it, but she didn't.
(B) She liked it, but he didn't.
(C) Both of them liked it.
(D) Neither of them liked it.

42. (A) That Helen is still in the hospital.
(B) That Helen's friend is still in the hospital.
(C) That Helen's brother is still in the hospital.
(D) That Helen's boy is still in the hospital.

43. (A) Take the children to the beach.
(B) Get her coat at the cleaner's.
(C) Take her and the children to dinner.
(D) Get something at the post office.

44. (A) Fifty cents.
(B) Seventy-five cents.
(C) Eighty cents.
(D) One dollar.

45. (A) She visited George's parents in Chicago.
(B) She visited her sister in Boston.
(C) She visited George's parents in Boston.
(D) She visited her sister in Chicago.

46. (A) In a doctor's office.
(B) In a clothing store.
(C) In a shoe repair shop.
(D) In a furniture store.

47. (A) That he has decided to look for a house.
(B) That he is moving to a new apartment.
(C) That he has bought a house.
(D) That he has decided to stay where he is.

48. (A) Thirty cents.
(B) Forty cents.
(C) Fifty cents.
(D) Sixty cents.

49. (A) In a bus station.
(B) In a ticket office.
(C) In a bank.
(D) In a furniture store.

50. (A) Six thirty (6:30).
(B) Seven o'clock (7:00).
(C) Seven thirty (7:30).
(D) Eight o'clock (8:00).

The overall mean score achieved by subjects from Sample I was 57.5%.

APPENDIX 2

Study 1: Steps in the Construction of the Stimuli

a) PRACTICE WORDS FOR HUNGARIAN SPEAKERS

1. maga
2. avval
3. bazsarózsa
4. faragas
5. apparátus
6. szakkatalógus
7. aggat
8. tasak
9. tavaly
10. kassa
11. akar
12. abban
13. rozzsal
14. baba
15. affajta
16. apadás

b) ACTUAL STIMULI FOR HUNGARIAN SPEAKERS

1. affa
2. akka
3. abba
4. ava
5. ava
6. aka
7. agga
8. azsa
9. affa
10. asa
11. asa
12. ava
13. afa
14. afa
15. avva
16. avva
17. azzsa
18. aba
19. akka
20. akka
21. aga
22. abba
23. avva
24. abba
25. aka
26. assa
27. akka
28. appa
29. appa
30. azsa
31. aba
32. afa
33. abba
34. apa
35. appa
36. agga
37. aga
38. aga
39. aka
40. assa
41. appa
42. apa
43. azsa
44. azzsa
45. affa
46. aga
47. azzsa
48. aba
49. azzsa
50. afa
51. assa
52. ava
53. agga
54. apa
55. azzsa
56. assa
57. asa
58. aba
59. afa
60. assa
61. apa
62. aba
63. agga
64. appa
65. abba
66. azsa
67. avva
68. avva
69. apa
70. asa
71. affa
72. aka
73. affa
74. agga
75. ava
76. aga
77. azsa
78. akka
79. asa
80. aka

c) RATING SHEET USED BY 6 NATIVE HUNGARIANS TO JUDGE ADEQUACY OF ACTUAL STIMULI

You are going to hear some sounds. Listen carefully. After each sound I want you to answer some questions.

What sound was it? (Write down the sound you heard.)	*How sure were you that it was this sound?* (See attached rating sheet.) Rating: 1	2	3	4	5
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
10.					
11.					
12.					
13.					
14.					
15.					
16.					
17.					
18.					
19.					
20.					
21.					
22.					
23.					
24.					
25.					
26.					
27.					
28.					
29.					
30.					
31.					
32.					
33.					
34.					
35.					
36.					
37.					
38.					
39.					
40.					

(Attached Rating Sheet)

Rate how sure you are on a scale going from 1 to 5, 1 being "not sure at all", and 5 being "absolutely certain", by putting an x under the appropriate number.

1. (not at all sure)
2. (slightly unsure)
3. (sure)
4. (very sure)
5. (absolutely certain)

d) SAMPLE OF A TAPE PRESENTED TO A SUBJECT

1. apa - apa
2. af̄a - af̄a
3. aʃ̄a - aʃ̄a
4. afa - af̄a
5. ava - ava
6. aka - aga
7. av̄a - aʒ̄a
8. aʃa - aʃa
9. aba - aba
10. aʒ̄a - aʒ̄a
11. ava - aʒa
12. aʃa - aʃa
13. afa - ava
14. ak̄a - aʃ̄a
15. aʒa - aʒa
16. apa - aka
17. ava - ava
18. ab̄a - ab̄a
19. afa - aʃa
20. aʒa - aʒ̄a
21. ak̄a - ak̄a
22. apa - afa
23. ak̄a - aḡa
24. ab̄a - av̄a
25. aga - aga
26. apa - ap̄a
27. aʃ̄a - aʃ̄a
28. aba - aba
29. apa - apa
30. af̄a - aʃ̄a
31. af̄a - af̄a
32. ap̄a - ap̄a
33. aʒa - aʒa
34. aḡa - aʒ̄a
35. aʃa - aʃ̄a
36. aḡa - aḡa
37. ab̄a - ab̄a
38. aʃa - aka
39. ap̄a - ab̄a
40. aga - aʒa
41. aga - aga
42. apa - aba
43. aka - aka
44. aba - ab̄a
45. aʃ̄a - aʒ̄a
46. ava - av̄a
47. ap̄a - ap̄a
48. aka - aka
49. ap̄a - ak̄a
50. af̄a - av̄a
51. ab̄a - aḡa
52. ak̄a - ak̄a
53. ap̄a - af̄a
54. aḡa - aḡa
55. aka - aʃa
56. afa - afa
57. aba - aga
58. aka - ak̄a
59. aba - ava
60. av̄a - av̄a
61. aga - aḡa
62. av̄a - av̄a
63. aʒ̄a - aʒ̄a
64. afa - afa

APPENDIX 3

Study 1: Procedure Followed by Assistant With Each Subject

INSTRUCTIONS À L'ASSISTANT

1. Pour les enfants de 4 à 6 ans, et de 6 à 8 ans

Nous allons jouer un jeu. C'est un jeu avec des choses que tu vas entendre par les écouteurs. Tu vas entendre des sons et j'aimerais que tu me dises si les sons sont pareils ou pas pareils.

Tiens, jouons un peu.

Aux 4-6 ans: Je vais dire deux mots, s'ils sont pareils, dis OUI, s'ils ne sont pas pareils, dis NON.
Aux 6-8 ans: Je vais dire deux mots, s'ils sont pareils, fais un rond avec ton crayon, s'ils ne sont pas pareils, fais un X. Écoutes bien:

CHAT - OISEAU

(Dites: "C'est ça" si l'enfant donne ou écrit la bonne réponse. Si non, expliquez que *chat* et *oiseau* ne sonnent pas pareils en mettant l'accent sur la prononciation.)

Et maintenant:

CHAT - CHAT

Est-ce que c'est pareil ou pas pareil?

(Si l'enfant semble avoir de la difficulté, continuez à faire l'exercice avec les paires suivantes:

BALLE - AUTO
BALLE - BALLE
MAISON - PAPILLON
PAPILLON - PAPILLON

Sinon, allez à l'exemple suivant.)

Maintenant on va faire la même chose mais avec des mots pas vrais (des mots que j'invente, pour jouer). Dis-mois, est-ce qu'ils sont pareils ou pas pareils ces mots-là (OUI pour pareils, NON pour pas pareils ou cercle pour pareil, X pour pas pareil selon l'âge).

ZIP - BAK

Puis:

BAK - BAK

(Continuez avec d'autres exemples, tels:

GUT - POK
POK - POK
VAP - GIZ
GIZ - GIZ

au besoin.)

Mais des fois, ça ne va pas être si facile que cela; tiens, maintenant, écoute-bien, dis-mois si c'est pareil ou pas pareil.

ZIP - ZOP
ZIP - ZIP

(et encore,

GAK - PAK
PAK - PAK
MAT - SAT
MAT - MAT

au besoin.)

(Pour les enfants de 4 à 6 ans, continuez avec 1a. Pour les enfants de 6 à 8 ans, continuez avec 1b.)

1a. Aux enfants de 4 à 6 ans

On va jouer le jeu comme ça. Chaque fois que tu as fini 2 devinettes, je te donnes un jeton rouge. Voyons combien de jetons tu pourras gagner. Hier, un petit garçon (ou fille, selon le cas) est venu(e), et regarde combien il (elle) a eu! Peux-tu en faire plus?

(C'est vous qui marquerez la réponse de l'enfant, OUI ou NON.) Soyez sûr que l'enfant a très bien compris ce qui est requis de lui -- donc pratiquez jusqu'à ce qu'il ait la bonne réponse.)

1b. Aux enfants de 6 à 8 ans

(Il faut que vous soyez sûr que l'enfant a très bien compris ce qui est requis de lui -- donc pratiquez jusqu'à ce qu'il ait la bonne réponse.)

Alors, tu mettras la réponse à la première devinette ici (en montrant du doigt au no. 1), puis, pour la deuxième devinette tu mettras ta réponse ici (au no. 2).

(Ici, il faudra bien le surveiller, pour être sûr qu'il sait où inscrire sa réponse. De toute façon, il faudra vérifier tout le temps pour qu'il ne saute pas de lignes.)

Aux 2 groupes d'âge

À toutes les 8 réponses, vous lui direz: "C'est très bien, ça va très bien", ou quelque chose de la sorte en guise d'encouragement.

2. Pour les groupes de 10 ans et plus

"Tu vas entendre des paires de mots qui ne veulent rien dire. Je veux que tu me répondes par écrit si les deux sons que tu auras entendus sont pareils ou différents. S'ils sont pareils, fais un O, s'ils sont différents, fais un X" (l'assistant doit en faire la démonstration -- assurez-vous que le sujet a du papier-brouillon et un crayon).

"Par exemple, si tu entendais ZIP - BAC que marquerais-tu?

Et si tu entendais BAK - BAK que marquerais-tu?"

(Si le sujet répond correctement, renforcez-le verbalement, sinon, corrigez-le discrètement.)

(Continuez ainsi avec les prochains trois exemples pour ceux qui ont réussi parfaitement les deux premiers. Pour ceux qui ont fait une erreur ou plus sur les deux premiers, continuez jusqu'à 4 performances consécutives parfaites.)

GUT - POK
POK - POK

VAP - GIZ
ZIP - ZOP
ZIP - ZIP
GAK - PAK
MAT - SAT

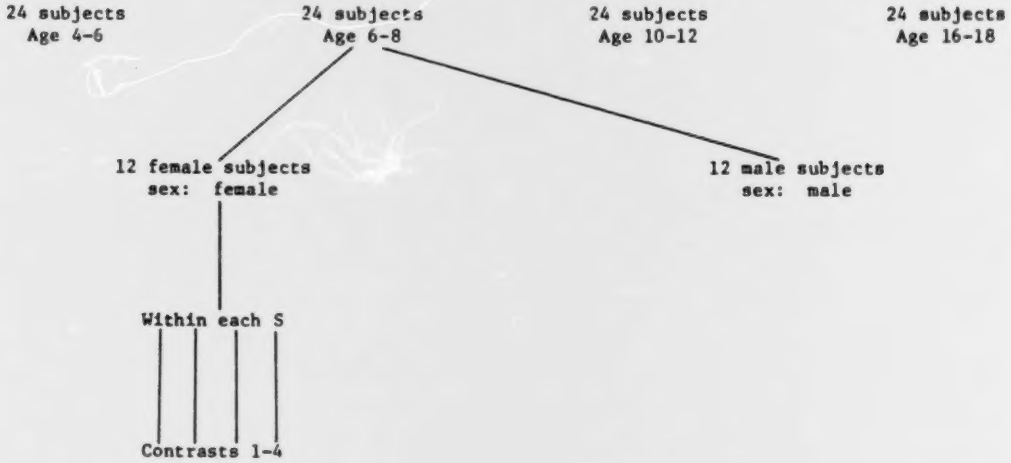
Durant la présentation des sons, renforcez (par exemple, par un "ça va très bien", "c'est bien") à toutes les *huit* réponses (donc huit fois en tout). Évitez à tout prix de donner quelque signe que ce soit autrement.

Aussi, faites très attention que le sujet ne saute pas par-dessus un numéro, étant donné qu'à ce moment-là on ne peut plus retourner en arrière.

Faites des notes sur tout événement ou observation qui sort de l'ordinaire durant le courant de l'expérience (faites-le sur la feuille où le nom du sujet est marqué).

APPENDIX 4

Study 1: Design of Study


24 subjects
Age 4-6
24 subjects
Age 6-8
24 subjects
Age 10-12
24 subjects
Age 16-18
12 female subjects
sex: female
12 male subjects
sex: male
Within each S
Contrasts 1-4

APPENDIX 5

Table A
Study 1. Analysis of Variance Table

Source	Error Term	SS	df	MS	F
G	S(GX)	213.402	3	71.134	30.32**
G1 vs G2	S(GX)	3.30	1	3.30	1.40
G2 vs G3	S(GX)	79.876	1	79.876	34.05**
G3 vs G4	S(GX)	5.28	1	5.28	2.25
X	S(GX)	0.603	1	0.603	0.26
C	SC(GX)	205.195	3	68.398	84.74**
GX	S(GX)	4.435	3	1.478	0.630
GC	SC(GX)	9.759	9	1.084	1.34
XC	SC(GX)	9.848	3	3.283	4.067**
X at C1	Satterthwaite	0.03	1	0.03	0.025
X at C2	"	1.42	1	1.42	1.19
X at C3	"	0.22	1	0.22	0.18
X at C4	"	8.84	1	8.84	7.43**
C at X1	SC(GX)	150.33	3	50.11	62.09**
C1, C2, C3 vs C4	SC(GX)	122.595	1	122.595	151.91**
C1 vs C4	SC(GX)	36.00	1	36.00	44.61**
C at X2	SC(GX)	64.71	3	21.57	26.73**
C1, C2, C3 vs C4	SC(GX)	46.962	1	46.962	58.19**
C1 vs C4	SC(GX)	10.296	1	10.296	12.758**
S(GX)	-	206.428	88	2.346	-
GXC	SC(GX)	8.501	9	0.945	1.17
G at X1C1	Satterthwaite	37.06	3	12.35	10.38**
Linear trend	"	28.30	1	28.30	23.78**
Quadratic trend	"	6.97	1	6.97	5.86*
G at X2C1	"	38.64	3	12.88	10.82**
Linear trend	"	32.68	1	32.68	27.46**
Quadratic trend	"	4.78	1	4.78	4.02*
G at X1C4	"	16.097	3	5.366	4.51**
Linear trend	"	13.21	1	13.21	11.10**
Quadratic trend	"	0.639	1	0.639	0.537
G at X2C4	"	64.97	3	21.66	18.20**
Linear trend	"	59.55	1	59.55	50.04**
Quadratic trend	"	4.07	1	4.07	3.42
SC(GX)	-	213.084	264	0.807	-
Satterthwaite approx. (S(GX,SC(GX))	-		268	1.19	-

Note. G = Age Factor : levels: 4-6 (G1), 6-8 (G2), 10-12 (G3), 16-18 (G4);

X = Sex Factor : levels: female (X1), male (X2);

C = Contrast Factor : levels: voicing (C1), place (C2), obstruction (C3), duration (C4).

*p < .05.

**p < .01.

APPENDIX 6

Study 2: Questions on Audition (For Subjects Age 18)

Questions and responses of Adult subjects for eligibility to study.

---

1. *Have you ever had any problems with your hearing?*
   Answer: No.

2. *Have you ever had any operations done to your ears?*
   Answer: No. (except for aesthetic surgery).

3. *Have you ever had to have tubes put in your ears due to recurrent or severe infections?*
   Answer: No.

4. *Have you ever had a hearing test done?*
   Answer: Yes or No.

If Yes for Q.4.

4a. *What were the results?*
Answer: There was no problem with my hearing; or
I could hear perfectly well.

APPENDIX 7

Study 2: Color Naming Test

(adapted from Stroop, 1935 (cited in Lambert, 1969))

a) CHART AS USED

(a brown-colored circle)	(a blue-colored circle)	(a red-colored circle)	(a green-colored circle)
(a red-colored circle)	(a green-colored circle)	(a green-colored circle)	(a blue-colored circle)
(a blue-colored circle)	(a brown-colored circle)	(a red-colored circle)	(a brown-colored circle)
(a green-colored circle)	(a blue-colored circle)	(a green-colored circle)	(a blue-colored circle)
(a brown-colored circle)	(a green-colored circle)	(a blue-colored circle)	(a red-colored circle)
(a red-colored circle)	(a red-colored circle)	(a brown-colored circle)	(a green-colored circle)
(a green-colored circle)	(a blue-colored circle)	(a red-colored circle)	(a red-colored circle)
(a brown-colored circle)	(a brown-colored circle)	(a blue-colored circle)	(a brown-colored circle)

b) MODE OF ADMINISTRATION

As can be seen in the chart, a matrix with 8 colored circles per row in 4 rows is used. Colors are distributed randomly so that each of 4 colors (red = rouge, green = vert, blue = bleu, and brown = brun) is equally represented. The colors are chosen in such a way that they are monosyllabic, both in French and in English. The matrix is set on a 12" by 8" cardboard. Each circle is approximately 1.75 cm in diameter; distance between circles within rows is about 1.5 cm and between rows is about 2 cm.

To be sure that the subject can name all 4 colors, the subject is first asked to name all 4 colors indicated by the experimenter one by one (randomly selected with the matrix in an upside down position).[*] He is then told (still with the matrix upside down), that when given the signal, he should start naming the color of every circle, from left to right, top row to bottom row (experimenter demonstrates with finger):

START HERE

(chart)

STOP

---

[*] If the subject did not know all or part of the color names in English, and if it was very very easy (that is, if the subject caught on the first time), the names of the colors were taught to the subject if he did not know them. Otherwise, only the French test was administered.

He is not allowed to skip any or make any errors (if errors *are* made, the experimenter alerts the Subject to the error and the Subject must correct it before proceeding further) (the same applies to skipped circles).

The experimenter starts counting time at the moment the subject starts uttering his first color and ends counting time when the subject ends uttering his last color.

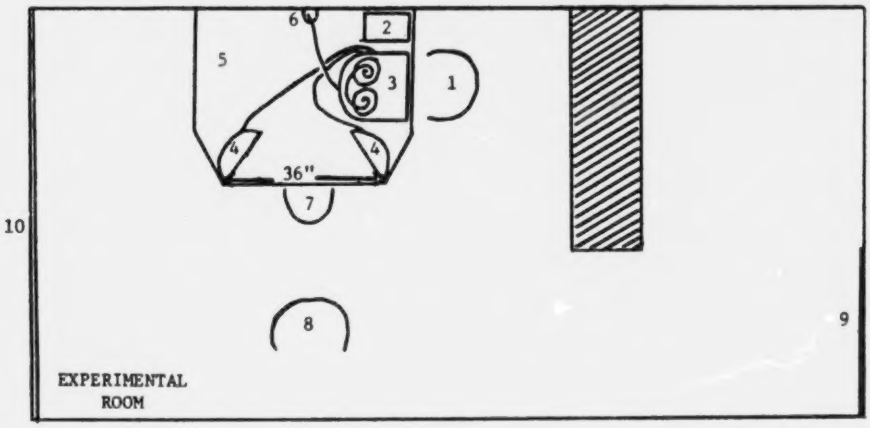
Subjects are first tested in English (although instructions are in French), then in French. This order (rather than counterbalancing) was chosen purposefully because we wanted to eventually get 2 groups: those who spoke English poorly (low bilinguals) versus those who spoke English very well (high bilinguals) and we hoped, by preventing a practice effect, to increase the variance of reaction times on the English task and thus to more easily separate out these two groups.

Two random arrangements of the matrix of colors were created: sample 1 and 2; if the subject received one of the two for his English test, he got the other one for his French test.

The Color Naming Test was administered exclusively by the experimenter.

APPENDIX 8

Study 2: Type of Setup for Running Study


6
2
5
3
1
4
4
36"
7
10
8
9
EXPERIMENTAL ROOM

Index

1. Blind assistant's chair
2. Response sheet
3. Tape recorder
4. Loudspeaker
5. Table
6. Socket
7. Subject's chair
8. Experimenter's chair
9. Door
10. Window

APPENDIX 9

Study 2: Instructions to Subjects Prior to Running Experiment

SET 1. (Type of Stimulus: CONSONANT WITHIN SPEECH; Type of Judgment: LOUDNESS)

a. Learning what they would hear and how to focus on the middle letter

"You are going to hear some words; one word will come through here (pointing to one loudspeaker) and the other will come through here (pointing to the other loudspeaker). The words will be, for example, aba, from here (pointing to one loudspeaker) and afa from here (pointing to another loudspeaker)" (although veridical examples were used, the pairings were not those that actually occurred in the experiment-proper). *FOR THE SIX-YEAR OLDS ONLY*: "Do you know your letters?" (i.e. of the alphabet) (If the subject said 'yes', the experimenter said) "You must listen only to the letter in the middle of the word". *FOR THE SIX-YEAR OLDS ONLY*: (If the subject said 'no', the experimenter thereafter used the word 'sound' rather than 'letter': e.g. you must listen only to the sound in the middle of the word). "For aba, what is the letter (sound) in the middle?" (If the subject answered 'b', the experimenter said) "That's right, it's 'b'." (If the subject answered 'bé' -- the French name for the letter -- the experimenter said) "Yes, that's the name of the letter, but how does it sound in that word?" (If the subject now answered 'b', the experimenter said) "That's right, it's 'b'. (If the subject still said 'bé' or claimed he did not know, the experimenter said) "It's 'b' -- listen to 'b' in aba, do you hear it?" (This was repeated till the subject said yes and produced the correct answer.) (The same procedure was then followed for afa. In most cases, subjects performed the task of tracking the middle letter's sound after two exemplars. If this was not enough, the other two stimuli were brought in -- again not in a pairing similar to that actually occurring in the experiment -- and the same procedure was followed as above. This was done with the four words as long as was necessary to get perfect performance. If the last two words had to be brought in, no case occurred in which the subject did not get, by himself, without prompting, the sounds of their middle letters.) (This was followed by the following instructions.)

b. Instruction in the discrimination of Loudness differences

"I will want you to listen to these middle letters (or sounds) and tell me which one is louder. Let's practice with sounds I will make, sounds that don't come from words." (Practice was then done with one obviously loud tone, and one obviously weak tone of variable pitches and in various orders produced by the experimenter; the subject had to say which of the two was louder, the first or the second. This was practiced till correct performance on two consecutive trials, and in fact most subjects performed perfectly on the first two trials).

(The same thing was then done, but with the sounds purportedly coming from the loudspeakers, and the subject's response this time had to be to point to the loudspeaker from which came the louder sound. Again, this was practiced till correct performance on two consecutive trials, and again most subjects performed perfectly on the first two trials).

(Finally, the same thing was done, but with the pairs of words used in a). First the subject had to say the middle letter (as it sounded in the word) while pointing to the loudspeaker it came from; then he had to point to the loudspeaker from which came the louder middle letter (or sound). Here practice was done on the two pairs cited in a) and perfect performance (which every one achieved) on both pairs only on the identification of the middle sound was required. Whatever loudspeaker was pointed to as the correct response for the louder middle letter, the subject was told: "Yes, that's what you have to do, point to the one which you think has the louder middle letter."

SET 2. (Type of Stimulus: CONSONANT WITHIN SPEECH; Type of Judgment: PITCH)

a. Learning what they would hear and how to focus on the middle letter

Same as for Set 1.

b. Instruction in the discrimination of Pitch differences

"I will want you to listen to these middle letters (or sounds) and tell me which one is higher. Let's practice with sounds I will make, sounds that don't come from words." (Practice was then done with one obviously high tone, and one obviously low tone of variable loudnesses and in various orders produced by the Experimenter: the subject had to say which of the two was higher, the first or the second. This was practiced till correct performance on two consecutive trials, and in fact most subjects performed perfectly on the first two trials).

(The same thing was then done, but with the sounds purportedly coming from the loudspeakers, and the subject's response this time had to be to point to the loudspeaker from which came the higher sound. Again, this was practiced till correct performance on two consecutive trials, and again most subjects performed perfectly on the first two trials).

(Finally, the same thing was done, but with the pairs of words used in a.) First, the subject had to say the middle letter (as it sounded in the word) while pointing to the loudspeaker it came from; then he had to point to the loudspeaker from which came the higher middle letter (or sound). Here practice was done on the two pairs cited in a) and perfect performance (which every one achieved) on both pairs, only on the identification of the middle sound, was required. Whatever loudspeaker was pointed to as the correct response for higher pitch, the subject was told: "Yes, that's what you have to do, point to the one which you think has the higher middle letter."

SET 3. (Type of Stimulus: CONSONANT EXTRACTED FROM SPEECH; Type of Judgment: LOUDNESS)

a. Learning what they would hear and how to focus on the non-speech sound

"You are going to hear some sounds; one sound will come through here (pointing to one loudspeaker) and the other will come through here (pointing to the other loudspeaker). The sounds will be very short, so you will have to listen very carefully in order not to miss them."

b. Instruction in the discrimination of Loudness differences

"I will want you to listen to these sounds and tell me which one is louder. Let's practice with sounds I will make." (Practice was then done with one obviously loud tone, and one obviously weak tone of variable pitches and in various orders produced by the experimenter; the subject had to say which of the two was louder, the first or the second. This was practiced till correct performance on two consecutive trials, and in fact most subjects performed perfectly on the first two trials.)

(The same thing was then done, but with the sounds purportedly coming from the loudspeakers, and the subject's response this time had to be to point to the loudspeaker from which came the louder sound. Again, this was practiced till correct performance on two consecutive trials, and again most subjects performed perfectly on the first two trials.)

SET 4. (Type of Stimulus: CONSONANT EXTRACTED FROM SPEECH; Type of Judgment: PITCH)

a. Learning what they would hear and how to focus on the non-speech sound

Same as in Set 3.

b. Instruction in the discrimination of Pitch differences

"I will want you to listen to these sounds and tell me which one is higher. Let's practice with sounds I will make". (Practice was then done with one obviously high tone, and one obviously low tone of variable loudnesses and in various orders produced by the Experimenter; the subject had to say which of the two was higher, the first or the second. This was practiced till correct performance on two consecutive trials, and in fact most subjects performed perfectly on the first two trials.)

(The same thing was then done, but with the sounds purportedly coming from the loudspeakers, and the subject's response this time had to be to point to the loudspeaker from which came the louder sound. Again, this was practiced till correct performance on two consecutive trials, and again most subjects performed perfectly on the first two trials).

(Note: the description in all four sets is a translation of the instructions, which were obviously in French. The terms used for *loud, weak, high, low,* were *fort, faible, aigu, sonore,* respectively.)

The experimenter then told the subject that he had to be quite certain of his answer before responding, and therefore was encouraged to ask to have the pairs of stimuli replayed until such time as he was sure.

APPENDIX 10

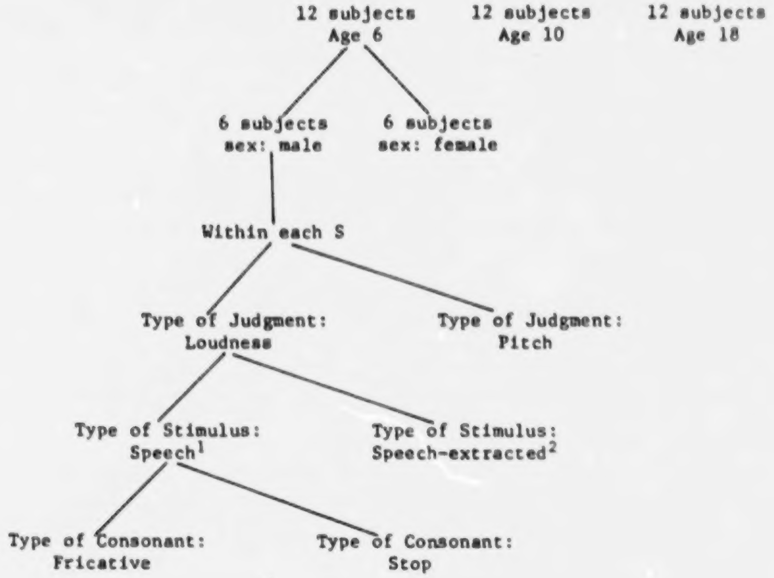
Study 2: Sample Response Sheet for Judgments of Pitch and Loudness of Speech and Speech-Extracted Consonants

	Side of Loudspeaker Pointed To	
	Left	Right
Type of Judgment= Pitch Type of Stimulus = Consonant extracted from speech		
1.	✓	
2.		✓
3.		✓
4.	✓	
Type of Judgment= Loudness Type of Stimulus = Consonant extracted from speech		
1.		✓
2.	✓	
3.	✓	
4.		✓
Type of Judgment= Pitch Type of Stimulus = Consonant within speech		
1.	✓	
2.	✓	
3.		✓
4.		✓
Type of Judgment= Loudness Type of Stimulus = Consonant within speech		
1.		✓
2.		✓
3.	✓	
4.	✓	

Name: *Jean de la Fontaine*
Age: *6*
Class: *11eme Grenat*
Order of Presentation:
Pitch then Loudness for Consonant extracted from speech then Consonant within speech

APPENDIX 11

Study 2: Design of Study


12 subjects
Age 6
12 subjects
Age 10
12 subjects
Age 18
6 subjects
sex: male
6 subjects
sex: female
Within each S
Type of Judgment:
Loudness
Type of Judgment:
Pitch
Type of Stimulus:
Speech[1]
Type of Stimulus:
Speech-extracted[2]
Type of Consonant:
Fricative
Type of Consonant:
Stop

---

[1] short-hand way of referring to a 'Consonant within Speech'

[2] short-hand way of referring to a 'Consonant extracted from Speech'

APPENDIX 12

Table B
Study 2: Analysis of Variance Table

Source	Error Term	SS	df	MS	F
A	S(AX)	69.44445	2	34.72222	0.0260
X	S(AX)	138.8889	1	138.8889	0.1042
J	SJ(AX)	34.72222	1	34.72222	0.0305
S_t	$SS_t(AX)$	33,368.06	1	33,368.06	14.3862**
C	SC(AX)	34.72222	1	34.72222	0.0420
AX	S(AX)	902.7776	2	451.3887	0.3385
AJ	SJ(AX)	1,111.111	2	555.5555	0.4878
XJ	SJ(AX)	312.4998	1	312.4998	0.2744
AS_t	$SS_t(AX)$	3,402.778	2	1,701.389	0.7335
XS_t	$SS_t(AX)$	34.72222	1	34.72222	0.0150
JS_t	$SJS_t(AX)$	40,138.89	1	40,138.89	28.6139**
AC	SC(AX)	486.1111	2	243.0555	0.2941
XC	SC(AX)	34.72222	1	34.72222	0.0420
JC	SJC(AX)	13,888.89	1	13,888.89	17.6991**
S_tC	$SS_tC(AX)$	8,888.888	1	8,888.888	15.4217**
S(AX)		40,000.00	30	1,333.333	
AXJ	SJ(AX)	1,875.000	2	937.4998	0.8232
AXS_t	$SS_t(AX)$	3,611.111	2	1,805.555	0.7784
AJS_t	$SJS_t(AX)$	12,152.78	2	6,076.388	4.3317*
AS_t at J1	Sat^{wte}: AS_t, AS_tJ	13,854.16	2	6,927.08	3.722*
AS_t at J2	Sat^{wte}: AS_t, AS_tJ	1,701.39	2	850.695	.4571
AS_t at J1					
A at S_t1 J1	S^{wt}: A, AS_t, AJ, AS_tJ	7,569.44	2	3,784.72	2.44
A at S_t2 J1	S^{wt}: A, AS_t, AJ, AS_tJ	6,736.12	2	3,368.06	2.175
AS_t at J1					
S_t at A1 J1	S^{wt}: S_t, S_tA, S_tJ, S_tAJ	6,302.09	1	6,302.09	3.386
S_t at A2 J1	S^{wt}: S_t, S_tA, S_tJ, S_tAJ	208.34	1	208.34	.112
S_t at A3 J1	S^{wt}: S_t, S_tA, S_tJ, S_tAJ	7,500.00	1	7,500.00	4.03*
AS_t at J2					
A at J2	S^{wt}: A, AJ	729.166	2	364.583	.295
S_t at J2	S^{wt}: S_t, JS_t	73,350.69	2	36,675.345	42.59**
XJS_t	$SJS_t(AX)$	1,250.000	1	1,250.000	0.8911
AXC	SC(AX)	902.7776	2	451.3887	0.5462
AJC	SJC(AX)	1,111.111	2	555.5555	0.7080
XJC	SJC(AX)	2,222.222	1	2,222.222	2.8319
AS_tC	$SS_tC(AX)$	2,152.778	2	1,076.389	1.8675
XS_tC	$SS_tC(AX)$	138.8889	1	138.8889	0.2410
JS_tC	$SJS_tC(AX)$	4,201.388	1	4,201.388	5.5505*
S_tC at J1	$S^{wt}(S_tC, S_tCJ)$	434.03	1	434.03	.651
S_tC at J2	$S^{wt}(S_tC, S_tCJ)$	12,656.25	1	12,656.25	18.98**
S_tC at J1					
S_t at J1	$S^{wt}(S_t, S_tJ)$	156.25	1	156.25	.08
C at J1	$S^{wt}(C, CJ)$	6,267.36	1	6,267.36	6.52*
S_tC at J2					
S_t at C1 J2	$S^{wt}(S_t, S_tC, S_tJ, S_tCJ)$	73,472.22	1	73,472.22	58.13**
S_t at C2 J2	$S^{wt}(S_t, S_tC, S_tJ, S_tCJ)$	14,575.62	1	14,575.62	11.53**

(continued on next page)

Source	Error Term	SS	df	MS	F
S_tC at J2					
C at S_t1 J2	$S^{wt}(C, CS_t, CJ, CS_tJ)$	20,000.00	1	20,000.00	27.17**
C at S_t2 J2	$S^{wt}(C, CS_t, CJ, CS_tJ)$	312.50	1	312.50	.425
SJ(AX)		34,166.67	30	1,138.889	
SS_t(AX)		69,583.33	30	2,319.444	
SC(AX)		24,791.67	30	826.3887	
$AXJS_t$	SJS_t(AX)	4,374.997	2	2,187.500	1.5594
AXJC	SJC(AX)	2,986.111	2	1,493.055	1.9027
AXS_tC	SS_tC(AX)	277.7776	2	138.8889	0.2410
AJS_tC	SJS_tC(AX)	902.7776	2	451.3887	0.5963
XJS_tC	SJS_tC(AX)	312.4998	1	312.4998	0.4128
SJS_t(AX)		42,083.33	30	1,402.778	
SJC(AX)		23,541.67	30	784.7222	
SS_tC(AX)		17,291.67	30	576.3887	
$AXJS_tC$	SJS_tC(AX)	625.0001	2	312.5001	0.4128
SJS_tC(AX)		22,708.33	30	756.9444	
Sat^{wte}: S_tC, S_tCJ			≈ 47	666.6665	
Sat^{wte}: C, CS_t, CJ, CS_tJ			118	736.11	
Sat^{wte}: AS_t, AS_tJ			≈ 57	1,861.111	
Sat^{wte}: S_t, S_tA, S_tJ, S_tAJ			≈ 57	1,861.111	
Sat^{wte}: A, AJ			≈ 60	1,236.1112	
Sat^{wte}: S_t, JS_t			≈ 57	1,861.111	

Note. A — Age Factor: levels: 6 (A1), 10 (A2), 18 (A3); X — Sex Factor: levels: female (X1), male (X2); J — Type of Judgment: levels: pitch (J1), loudness (J2); S_t — Type of Stimulus: levels: speech (S_t1)[a], speech-extracted (S_t2)[b]; C — Type of Consonant: levels: fricative (C1), stop (C2).

[a] short-hand way of referring to a 'Consonant within Speech'

[b] short-hand way of referring to a 'Consonant extracted from Speech'

* $p < .05$.

** $p < .01$.

APPENDIX 13

Study 3: Linguistic Criteria for Subject Inclusion in Study

a. Parents completed the following:

Questionnaire on Subject's Degree of Bilingualism:

Age-adjusted and refined adaptation of the one used by Vaid and Lambert (1979) (Used by permission).

1. Nom de l'enfant: ______________________________

2. Sexe: ______________________________

3. Sa date de naissance: ______________________________

4. Son école: ______________________________

5. Année d'études: Donnez l'année dans laquelle il (elle) se trouve *actuellement* (par exemple: Primaire: 2ème)

   Préscolaire: ______________________ (donnez l'année exacte)
   Maternelle: ______________________ (donnez l'année exacte)
   Primaire: ______________________ (donnez l'année exacte)
   Secondaire: ______________________ (donnez l'année exacte)

6. Dans quel pays est-il (elle) né(e)?

   ____

7. Quelle est sa langue maternelle (c'est-à-dire la langue qu'il (elle) a apprise en premier)?

   ____

8. S'il (si elle) connaît d'autres langues que sa langue maternelle, à quel âge les a-t-il (elle) apprises?

   (Écrivez chacune de ses langues secondes sur la ligne correspondant à l'âge auquel cette langue a été apprise)

Écrivez ci-dessous chaque langue seconde pour laquelle cela s'applique

	Écrivez ci-dessous chaque langue seconde pour laquelle cela s'applique
- en même temps que la langue maternelle: durant sa première année:	______________________
- à 1, 2ans:	______________________
- à 3, 4 ans:	______________________
- à 5, 6 ans:	______________________
- à 7, 8 ans:	______________________
- à 9, 10 ans:	______________________
- à 11, 12 ans:	______________________
- à 13, 14 ans:	______________________
- à 15 ans et plus:	______________________

9. Décrivez comment il (elle) a appris sa (ou ses) langue(s) seconde(s). Décrivez pour chaque langue:

(Notez que plus d'un contexte peut s'appliquer à une langue donnée: par exemple, l'enfant peut avoir appris l'allemand et à la maison et aussi lors d'un voyage en Allemagne).

	Écrivez ci-dessous chaque langue seconde pour laquelle cela s'applique	Donnez ci-dessous des détails par langue
- à la maison		
- avec des copains, dans la rue		
- à l'école		
- dans un cours spécialisé		
- dans un camp d'été		
- dans une autre province, en voyage		
- dans un autre pays		

10. Décrivez de quelle façon il (elle) a appris sa (ou ses) langue(s) seconde(s). Décrivez pour chaque langue:

(Notez ici aussi que plus d'une façon peut s'appliquer à une langue donnée).

	Écrivez ci-dessous chaque langue seconde pour laquelle cela s'applique	Donnez ci-dessous des détails par langue
- surtout en parlant		
- surtout en écoutant		
- surtout en lisant		
- surtout en écrivant		

11. Je veux savoir à quel point il (elle) connaît *TOUTES SES LANGUES* (Y INCLUT LA LANGUE MATERNELLE):

c'est-à-dire comment il (elle) écrit
comment il (elle) parle
comment il (elle) lit
comment il (elle) comprend

CHACUNE de ses langues connues.

Une fois que vous aurez fait votre évaluation, pour chaque critère dans chaque langue, je vous prierais de me donner le *numéro correspondant à votre évaluation*.

Voici la liste des diverses évaluations possibles ainsi que de leurs numéros correspondants.

Votre évaluation	**Numéro à donner**
Presque pas	1
Très mal	2
Mal	3
Comme ci, comme ça	4
Bien	5
Très bien	6
Parfaitement	7

(N'OUBLIEZ PAS DE DONNER POUR *CHAQUE LANGUE, QUATRE CHIFFRES* EN TOUT)

	Évaluation de			
Écrivez ci-dessous la langue	la langue écrite	la langue parlée	la langue lue	la langue comprise
________ (langue maternelle)	________	________	________	________
________ (langue seconde)	________	________	________	________
________ (langue seconde)	________	________	________	________
________ (langue seconde)	________	________	________	________

12. Je veux aussi savoir combien il (elle) utilise *CHACUNE DE SES LANGUES* (Y INCLUT LA LANGUE MATERNELLE):

Je vous demanderais d'évaluer la fréquence d'utilisation sur la base de la fréquence avec laquelle

il (elle) l'écrit
il (elle) la parle
il (elle) la lit
il (elle) l'entend

Cette fois-ci, je vous demande d'arriver à *une* évaluation par langue connue, mais à une évaluation de fréquence faite sur la base des quatre critères de fréquence d'utilisation cités ci-haut.

Une fois que vous aurez fait votre évaluation, pour chaque langue, je vous prierais de me donner le *numéro correspondant à votre évaluation.*

Voici une liste des diverses évaluations de fréquences d'utilisation possibles ainsi que de leurs numéros correspondants.

Votre évaluation	**Numéro à donner**
Presque pas	1
Très peu	2
Peu	3
De temps en temps	4
Souvent	5
Très souvent	6
Presque tout le temps	7

(N'OUBLIEZ PAS DE DONNER POUR *CHAQUE LANGUE, UN CHIFFRE*)

Écrivez ci-dessous la langue	Évaluation de la fréquence d'utilisation de la langue
(langue maternelle)	
(langue seconde)	
(langue seconde)	
(langue seconde)	

13. Est-ce qu'il y a des langues qu'il (elle) connaissait mieux à un âge plus jeune qu'à présent?

Oui ____________ (veuillez cocher) Non ____________ (veuillez cocher)

Si vous avez répondu Oui, quelle(s) langue(s)? ______________________________

14. Quelle(s) langue(s) connaissez-vous, vous ses parents?

	Veuillez inscrire les langues connues ci-dessous
Sa mère:	
Son père:	

15. Dans quelle(s) langue(s) parle-t-il (elle) avec les personnes suivantes: (Si l'enfant parle plus qu'une langue avec une personne, soulignez la langue parlée plus fréquemment avec cette personne, s'il y a lieu)

	Écrivez ci-dessous la langue (ou les langues) parlée(s) avec la personne (ou les personnes) en question
Avec sa mère:	
Avec son père:	
Avec ses frères et soeurs:	
Avec ses amis:	
Avec lui-même:	
Avec d'autres personnes:	

16. Quelle(s) langue(s) utilise-t-il (elle) lorsqu'il (elle) parle de certains sujets: (Si l'enfant utilise plus qu'une langue par sujet, soulignez la langue utilisée plus fréquemment, s'il y a lieu)

	Écrivez ci-dessous la langue (ou les langues) parlée (parlées) pour chaque sujet
- Sujet: Discussions sur la famille:	
- Sujet: Discussions sur choses sociales, tel que sorties, amis, sports:	
- Sujet: Discussions sur sujets scolaires, tel que devoirs, examens:	

b. Subjects were assigned a score to each of 4 factors judged to be important constituents for our overall measure of degree of bilingualism:

i) the four factors were the following:

Factor 1. Age of acquisition of second language
Factor 2. Comprehension of second language
Factor 3. Production of second language
Factor 4. Current usage of second language (frequency, context, and content).

The questions relevant to the scoring of each factor were the following:

(RELEVANT TO: AGE OF ACQUISITION OF SECOND LANGUAGE)

8. S'il (si elle) connait d'autres langues que sa langue maternelle, à quel âge les a-t-il (elle) apprises?

(Écrivez chacune de ses langues secondes sur la ligne correspondant à l'âge auquel cette langue a été apprise)

Écrivez ci-dessous chaque langue seconde pour laquelle cela s'applique

- en même temps que la langue maternelle: durant sa première année: ________________
- à 1, 2ans: ________________
- à 3, 4 ans: ________________
- à 5, 6 ans: ________________
- à 7, 8 ans: ________________
- à 9, 10 ans: ________________
- à 11, 12 ans: ________________
- à 13, 14 ans: ________________
- à 15 ans et plus. ________________

(RELEVANT TO: COMPREHENSION OF SECOND LANGUAGE)

(RELEVANT TO: PRODUCTION OF SECOND LANGUAGE)

11. Je veux savoir à quel point il (elle) connait *TOUTES SES LANGUES* (Y INCLUT LA LANGUE MATERNELLE):

c'est-à-dire comment il (elle) écrit
comment il (elle) parle
comment il (elle) lit
comment il (elle) comprend

CHACUNE de ses langues connues.

Une fois que vous aurez fait votre évaluation, pour chaque critère dans chaque langue, je vous prierais de me donner le *numéro correspondant à votre évaluation.*

Voici la liste des diverses évaluations possibles ainsi que de leurs numéros correspondants.

Votre évaluation	Numéro à donner
Presque pas	1
Très mal	2
Mal	3
Comme ci, comme ça	4
Bien	5
Très bien	6
Parfaitement	7

(N'OUBLIEZ PAS DE DONNER POUR *CHAQUE LANGUE, QUATRE CHIFFRES* EN TOUT)

	Évaluation de			
Écrivez ci-dessous la langue	la langue écrite	la langue parlée	la langue lue	la langue comprise
(langue maternelle)				
(langue seconde)				
(langue seconde)				
(langue seconde)				

(RELEVANT TO UTILIZATION OF SECOND LANGUAGE: FREQUENCY, CONTEXT, CONTENT)

12. Je veux aussi savoir combien il (elle) utilise *CHACUNE DE SES LANGUES* (Y INCLUT LA LANGUE MATERNELLE):

Je vous demanderais d'évaluer la fréquence d'utilisation sur la base de la fréquence avec laquelle

il (elle) l'écrit
il (elle) la parle
il (elle) la lit
il (elle) l'entend

Cette fois-ci, je vous demande d'arriver à *une* évaluation par langue connue, mais à une évaluation de fréquence faite sur la base des quatre critères de fréquence d'utilisation cités ci-haut.

Une fois que vous aurez fait votre évaluation, pour chaque langue, je vous prierais de me donner le *numéro correspondant à votre évaluation.*

Voici une liste des diverses évaluations de fréquences d'utilisation possibles ainsi que de leurs numéros correspondants.

Votre évaluation	Numéro à donner
Presque pas	1
Très peu	2
Peu	3
De temps en temps	4
Souvent	5
Très souvent	6
Presque tout le temps	7

(N'OUBLIEZ PAS DE DONNER POUR *CHAQUE LANGUE, UN CHIFFRE*)

Écrivez ci-dessous la langue	Évaluation de la fréquence d'utilisation de la langue
(langue maternelle)	
(langue seconde)	
(langue seconde)	
(langue seconde)	

15. Dans quelle(s) langue(s) parle-t-il (elle) avec les personnes suivantes: (Si l'enfant parle plus qu'une langue avec une personne, soulignez la langue parlée plus fréquemment avec cette personne, s'il y a lieu)

Écrivez ci-dessous la langue (ou les langues) parlée(s) avec la personne (ou les personnes) en question

Avec sa mère: ____________________
Avec son père: ____________________
Avec ses frères et soeurs: ____________________
Avec ses amis: ____________________
Avec lui-même: ____________________

16. Quelle(s) langue(s) utilise-t-il (elle) lorsqu'il (elle) parle de certains sujets: (Si l'enfant utilise plus qu'une langue par sujet, soulignez la langue utilisée plus fréquemment, s'il y a lieu)

Écrivez ci-dessous la langue (ou les langues) parlée (parlées) pour chaque sujet

- Sujet: Discussions sur la famille: ____________________
- Sujet: Discussions sur choses sociales, tel que sorties, amis, sports: ____________________
- Sujet: Discussions sur sujets scolaires, tel que devoirs, examens: ____________________

ii) each factor was scored in the following way:

FACTOR 1: Age of Acquisition of Second Language (Question 8)

The scoring here was adjusted to each age level so as to give age-independent results. At one extreme (never - does not speak a second language), the 1.0 value was assigned, at the other (together with mother tongue), the 10 value was assigned. The scale in between 1.0 and 10.0 was then divided symmetrically to correspond to the remaining ages (from birth to now), two years at a time.

Ages 6 - 8

Score	*Answers on Question 8*
1	never - does not speak a second language
3.25	age 5, 6
5.5	age 3, 4
7.75	age 1, 2
10	together with mother tongue

Ages 10 - 12

Score	*Answers on Question 8*
1	never - does not speak a second language
2.5	age 9, 10
4	age 7, 8
5.5	age 5, 6
7	age 3, 4
8.5	age 1, 2
10	together with mother tongue

Ages 16 - 19

Score	*Answers on Question 8*
1	never - does not speak a second language
2	age 15 and above
3	age 13 - 14
4	age 11 - 12
5	age 9 - 10
6	age 7 - 8
7	age 5 - 6
8	age 3 - 4
9	age 1, 2
10	together with mother tongue

FACTOR 2: Comprehension of Second Language
(Question 11, under *la langue comprise*)

Here the *ratio* of the evaluation given for the second language compared to the evaluation given for the mother tongue was the measure of interest. A ratio of 0 was given a score of 1.0 (i.e. unilingual), and a ratio of 1 was given a score of 10 (i.e. very bilingual), and the scale in between 1.0 and 10.0 was divided symmetrically in nine parts.

Score	*Answers on Question 11 (section "comprise")*
1	ratio S.L.* : M.T.** = 0 (does not understand S.L. or does not have a S.L.)
2	S.L. : M.T. = .2 or .1
3	S.L. : M.T. = .3
4	S.L. : M.T. = .4
5	S.L. : M.T. = .5
6	S.L. : M.T. = .6
7	S.L. : M.T. = .7
8	S.L. : M.T. = .8
9	S.L. : M.T. = .9
10	S.L. : M.T. = 1

---

* S.L.: abbreviation for second language.

** M.T.: abbreviation for mother tongue.

FACTOR 3: Production of Second Language (Question 11, under *la langue parlée*)

Here again, the *ratio* of the evaluation given for the second language compared to the evaluation given for the mother tongue was the measure of interest. A ratio of 0 was given a score of 1.0 (i.e. unilingual), and a ratio of 1 was given a score of 10 (i.e. very bilingual), and the scale in between 1.0 and 10.0 was divided symmetrically in nine parts.

Score	*Answers on Question 11 (section "parlée")*
1	ratio S.L.[*] : M.T.[**] = 0 (does not understand S.L. or does not have a S.L.)
2	S.L. : M.T. = .2 or .1
3	S.L. : M.T. = .3
4	S.L. : M.T. = .4
5	S.L. : M.T. = .5
6	S.L. : M.T. = .6
7	S.L. : M.T. = .7
8	S.L. : M.T. = .8
9	S.L. : M.T. = .9
10	S.L. : M.T. = 1 or > 1

FACTOR 4: Current Usage of Second Language (This factor was based on responses to three questions: Questions 12, 15, 16)

Each question was first given a score from 1.0 to 10.0 (1.0 corresponding to unilingual, 10.0 to highly bilingual).

For *Question 12*, the scoring was as follows: the *ratio* of the evaluation given for the second language compared to the evaluation given for the mother tongue was the measure of interest. A *ratio* of 0 was given a score of 1.0 (i.e. unilingual), and a ratio of 1 was given a score of 10 (i.e,. very bilingual), and the scale in between 1.0 and 10.0 was divided symmetrically in nine parts.

For *Question 15*, the scoring was as follows: if only the mother tongue was used for all five categories, a score of 1.0 (i.e. unilingual) was assigned. If the second language was spoken as often as or more often than the mother tongue for all five categories, a score of 10.0 (i.e. strongly bilingual) was assigned, and the scale in between 1.0 and 10.0 was divided symmetrically in nine parts with the number of categories in which the second language equalled or surpassed the mother tongue decreasing as the score decreased from 10.0 to 1.0.

For *Question 16*, the scoring was as follows: if only the mother tongue was used for all three categories, a score of 1.0 (i.e. unilingual) was assigned: if the second language was spoken as often as or more often than the mother tongue for all three categories, a score of 10.0 (i.e. strongly bilingual) was assigned. The scale in between 1.0 and 10.0 was divided symmetrically in nine parts; the number of categories in which the second language equalled or surpassed the mother tongue decreased as the score decreased from 10.0 to 1.0; also, for any given number of categories in which the second language equalled or surpassed the mother tongue, when any of these categories included the category 'Sujet: Discussions sur la famille', the subject was assigned a higher score for that question than when any of these categories did not include the category 'Sujet: Discussions sur la famille'.

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[*] S.L.: abbreviation for second language.

[**] M.T.: abbreviation for mother tongue.

Score	*Answers on Question 12*
1	ratio S.L.[*] : M.T.[**] = 0 (does not understand or does not have a S.L.)
2	S.L. : M.T. = .1, .2
3	S.L. : M.T. = .3
4	S.L. : M.T. = .4
5	S.L. : M.T. = .5
6	S.L. : M.T. = .6
7	S.L. : M.T. = .7
8	S.L. : M.T. = .8
9	S.L. : M.T. = .9
10	S.L. : M.T. = 1 or > 1

Score	*Answers on Question 15*
1	M.T.[**] for all five categories
2	S.L.[*] and M.T. (but M.T. >) for one or two categories
3	S.L. and M.T. (but M.T. >) for three categories
4	S.L. and M.T. (but M.T. >) for four categories
5	S.L. and M.T. (but M.T. >) for five categories *or* S.L. ≥ M.T. for one, two categories other than "mother" or "father"
6	S.L. ≥ M.T. for category: with mother *or* with father
7	S.L. ≥ M.T. for category: with mother, with father
8	S.L. ≥ M.T. for three categories
9	S.L. ≥ M.T. for four categories
10	S.L. ≥ M.T. for all five categories

Score	*Answers on Question 16*
1	M.T.[**] for all three categories
2	S.L.[*] and M.T. (but M.T. >) for one or two categories excluding "famille"
3	S.L. and M.T. (but M.T. >) for one category including "famille"
4	S.L. and M.T. (but M.T. >) for two categories including "famille"
5	S.L. and M.T. (but M.T. >) for three categories
6	S.L. ≥ M.T. for one category excluding "famille"
7	S.L. ≥ M.T. for one category including "famille"
8	S.L. ≥ M.T. for two categories excluding "famille"
9	S.L. ≥ M.T. for two categories including "famille"
10	S.L. ≥ M.T. for all three categories

Each Question's score was then multiplied by .3333 (so that the three Questions would participate equally in the final score) and the resulting scores of the three questions were added: this gave then a score of from 1.0 to 10.0 (1 corresponding to unilingual, 10 to highly bilingual) for that factor.

c. The final score for degree of bilingualism was arrived at thus:

i) the factors were weighted as follows:

Factor		*Weight*
1	Age of Acquisition of Second Language	.1
2	Comprehension of Second Language	.3
3	Production of Second Language	.4
4	Current Usage of Second Language	.2

---

[*] S.L.: abbreviation for second language.

[**] M.T.: abbreviation for mother tongue.

The reasons for assigning these weights were the following. It was our intention to get a final global score going from 1.0 (i.e. unilingual) to 10.0 (i.e. strongly bilingual) on the basis of the four factors. Thus the weights had to add up to 1.0. As mentioned in the text, we arbitrarily decided to assign slightly more weight to measures of productive abilities (Factors 3, 4, 1) than to measures of lexical access abilities (Factors 2, 4, 1) Thus the sum of the weights assigned to factors 3, 4, and 1 would have to exceed the sum of the weights assigned to factors 2, 4, and 1. Also, as mentioned in the text, for productive abilities, factor 3 was a much better predictor than factor 4; for lexical access abilities, factor 2 was a much better predictor than factor 4. Finally, factor 1 was postulated, purely on intuitive grounds, to be a weak predictor of both productive abilities and lexical access abilities. As such, it is postulated to be the factor with the least weight.

ii) Each Subject's score for a given factor was then multiplied by this weight and all weighted factors' scores were added to give us our measure of degree of bilingualism. The final rating went from 1.0 to 10.0 -- 1.0 indicating unilingualism, 10.0 indicating strong bilingualism.

APPENDIX 14

Study 3: Selection of Subjects on Basis of Auditory History

a) Questions on Audition

A-t-il (elle) jamais eu des problèmes avec ses oreilles ou son audition:

Entend-il (elle) mal?
A-t-il (elle) eu des tubes dans les oreilles?
A-t-il (elle) eu une opération aux oreilles?
A-t-il (elle) eu des tests d'audition indiquant qu'il (elle) entendait mal certaines fréquences?

Oui ________ (veuillez cocher) Non __________ (veuillez cocher)

Si vous avez répondu Oui, veuillez me décrire, en détail, la nature de son problème:

____
____
____

b) Selection Criteria

Subjects were eliminated from the study if they reported any of the following:

- a diagnosed hearing difficulty following a hearing test
- an operation to the ears (except for aesthetic surgery)
- tubes inserted in the ears due to recurrent or severe infections
- recurrent or severe ear infections

APPENDIX 15

Study 3: List of French Words From Which CV's and VC's Were Derived*

Order: CV

Consonant	Vowel: ɛ	i	o
p	paix	pis	pau(vre)
b	(ra)bais**	bi(s)	beau
t	taie	ti(c)	tau(dis)
d	(ca)det	dit	do
k	qu'est-(ce)	qui	co(co)
g	gue(t-apens)	Guy	(fa)gôt

Order: VC

Consonant	Vowel: ɛ	i	o
p	(gu)êpe	(équ)ipe	(t)aupe
b	(f)aib(le)*****	ib(iscus)	aube
t	(pr)ête****	(r)it(uel)	haute
d	aide	(r)ide	(M)aude
k	ec(stase)***	(t)ic	(roc)occ(o)
g	aig(le)	(d)igue	aug(ure)

---

* See next page.
** See next page.
*** See next page.
**** See next page.
***** See next page.

* A number of words were wrongly syllabified; they are listed below, together with the syllable (CV or VC) they were presumed to contain, and together with a correct alternative.

CV or VC	Wrong Example	Correct alternative
kɛ	qu'est-(ce)	qué(ter)
bi	bi(s)	bi(zarre)
ti	ti(c)	ti(ret)
po	pau(vre)	po(teau)
ɛp	(gu)êpe	hep(tagone)
ɛb	(f)aib(le)	heb(domadaire)
ɛt	(pr)ête	êtes(vous)
ɛg	aig(le)	e(zact)
id	(r)ide	Ides (de Mars)
ik	(t)ic	hic
ig	(d)igue	ig(nifuge)

These errors are hopefully not too serious for the following two reasons:

First, they cover quite generally all three types of contrasts, p/b, t/d, k/g, and
second, as can be seen in Appendix 16, section b., speakers had to say only the part of the word NOT in brackets.

** The portions of each word, not in brackets, represents the actual CV or VC, as listed.

*** Although some words may seem to be misspelled (e.g. ec(stase), ib(iscus), this presentation was done voluntarily in order to highlight the syllabic organisation rather than the idiosyncratic sometimes confusing spelling (i.e. extase, hibiscus).

**** Because this word has two meanings, one of which is pronounced with a long è, the other with a short è, this may have created some ambiguity in the reader, thus possibly giving rise to a less than optimal stimulus.

***** It should be noted that variations in vocalic lengths, or attack such as in aide vs (f)aib(le), - though not strictly randomized - are welcome additional variations in the context of the desired variable spectrographic profiles of given consonants.

APPENDIX 16

Study 3: Speaker's Reading List

a. **Actual List**

1. aug(ure)*
2. aig(le)
3. (gu)êpe
4. (r)it(uel)
5. gue(t-apens)
6. (t)ic
7. aube
8. (f)aib(le)
9. paix
10. (ca)det
11. (M)aude
12. (équ)ipe
13. aide
14. tau(dis)
15. (roc)occ(o)
16. Guy
17. haute
18. aig(le)
19. ib(iscus)
20. dit
21. pau(vre)
22. (équ)ipe
23. (ra)bais
24. paix
25. (gu)êpe
26. (M)aude
27. (r)ide
28. Guy
29. qu'est-(ce)
30. (équ)ipe
31. aug(ure)
32. (t)aupe
33. (ra)bais
34. ti(c)
35. (M)aude
36. ib(iscus)
37. taie
38. paix
39. (ca)det
40. Guy
41. tau(dis)
42. qui
43. qu'est-(ce)
44. (M)aude
45. (d)igue
46. (t)aupe
47. ti(c)
48. (f)aib(le)
49. ec(stase)
50. gue(t-apens)
51. aig(le)
52. (t)aupe
53. ti(c)
54. dit
55. (r)ide
56. aube
57. (r)it(uel)
58. aide
59. (r)ide
60. aug(ure)
61. (r)it(uel)
62. haute
63. (ca)det
64. (fa)gôt
65. (d)igue
66. qu'est-(ce)
67. pis
68. qui
69. bi(s)
70. (équ)ipe
71. pau(vre)
72. haute
73. dit
74. taie
75. (ra)bais
76. aig(le)
77. beau
78. (d)igue
79. paix
80. co(co)
81. tau(dis)
82. (ca)det
83. ib(iscus)
84. ti(c)
85. (fa)gôt
86. (f)aib(le)
87. qu'est-(ce)
88. bi(s)
89. aube
90. (ra)bais
91. Guy
92. ec(stase)
93. (gu)êpe
94. taie
95. (t)ic
96. (r)it(uel)
97. gue(t-apens)
98. co(co)
99. pis
100. do
101. dit
102. gue(t-apens)
103. qui
104. pau(vre)
105. pis
106. (t)ic
107. (pr)ête
108. (ra)bais
109. (M)aude
110. pis
111. aide
112. do
113. beau
114. pau(vre)
115. (r)it(uel)
116. (roc)occ(o)
117. aube
118. (pr)ête
119. (t)ic
120. (fa)gôt
121. aide
122. (équ)ipe
123. (t)ic
124. taie
125. co(co)
126. (ca)det
127. (d)igue
128. (fa)gôt
129. aug(ure)

---

*Speakers were recorded reading aloud only that part of the word not in brackets.

130. (gu)êpe
131. (pr)ête
132. qu'est-(ce)
133. aube
134. ec(stase)
135. tau(dis)
136. beau
137. co(co)
138. aug(ure)
139. ec(stase)
140. (f)aib(le)
141. (d)igue
142. Guy
143. do
144. (t)aupe
145. ib(iscus)
146. beau
147. (roc)occ(o)
148. beau
149. bi(s)
150. (gu)êpe
151. (r)ide
152. bi(s)
153. pau(vre)
154. (pr)ête
155. aide
156. qui
157. taie
158. (pr)ête
159. (roc)occ(o)
160. ti(c)
161. (t)aupe
162. ec(stase)
163. qui
164. ib(iscus)
165. pis
166. (h)aute
167. (f)aib(le)
168. tau(dis)
169. (roc)occ(o)
170. gue(t-apens)
171. co(co)
172. do
173. dit
174. (h)aute
175. (fa)gôt
176. paix
177. bi(s)
178. do
179. (r)ide
180. aig(le)

b. Mode of Recording Speaker

Each speaker (individually) was told that his voice would be recorded as he said some words or parts of words.

At first the subject was instructed to read aloud the first 20 words.

Then, he was instructed to read the same list again, but this time reading aloud only that part of the word not in brackets; that is, he was told to read the whole word but to read silently the parts in brackets and aloud the rest (for example, for gue(t-apens), to produce only the gɛ sound audibly, or for (roc)occ(o), to produce only the ok sound audibly). He was instructed to read those off as naturally as possible, allowing three to four seconds pause between words. This was practiced till the naturalness of the voice, the length of the lag and the intensity of the voice was suitable to the experimenter.

Then, the speaker's voice was recorded in nine segments (for the 180 words), with a few minutes' rest between segments.

APPENDIX 17

Study 3: Sets of Stimuli Used for Acoustic Categorization Task

Order: Forward

1. ik ik ik ik ik ik ↑* ig ig
2. εb εb ↑ εp εp εp εp εp εp
3. go go go go go ↑ ko ko ko
4. tε tε tε tε tε tε ↑ dε dε
5. εg εg ↑ εk εk εk εk εk εk
6. it it it it ↑ id id id id
7. pi pi pi pi pi ↑ bi bi bi
8. do do do ↑ to to to to to
9. pε pε pε pε ↑ bε bε bε bε
10. ob ob ob ↑ op op op op op

---

* Upward arrow indicates place within the set at which element changes.

Order: Backward

1.	ob	ob	ob ↑	op	op	op	op	op
2.	pɛ	pɛ	pɛ	pɛ ↑	bɛ	bɛ	bɛ	bɛ
3.	do	do	do ↑	to	to	to	to	to
4.	pi	pi	pi	pi	pi ↑	bi	bi	bi
5.	it	it	it	it ↑	id	id	id	id
6.	ɛg	ɛg ↑	ɛk	ɛk	ɛk	ɛk	ɛk	ɛk
7.	tɛ	tɛ	tɛ	tɛ	tɛ	tɛ ↑	dɛ	dɛ
8.	go	go	go	go	go ↑	ko	ko	ko
9.	ɛb	ɛb ↑	ɛp	ɛp	ɛp	ɛp	ɛp	ɛp
10.	ik	ik	ik	ik	ik	ik ↑	ig	ig

APPENDIX 18

Study 3: Sets of Stimuli Used for Linguistic Categorization Task

Order: Forward

1.	pε	op	ip ↑*	bo	εb	bi	ob	bε
2.	id	dε ↑	ot	tε	it	to	εt	it
3.	ok	kε	ki	εk ↑	go	ig	gε	og
4.	ti	ot	tε	it	to ↑	εd	di	do
5.	εb	bi ↑	op	ip	po	εp	op	pi
6.	og	gε	gi	go	ig	εg ↑	ko	ik
7.	po	εp	ip ↑	bo	εb	bi	ob	ib
8.	tε	it	εt	to	ti ↑	od	εd	di
9.	gε	ig	εg	og	gi	gε ↑	ok	kε
10.	εb	bo	bi	ob ↑	pε	op	εp	pi

---

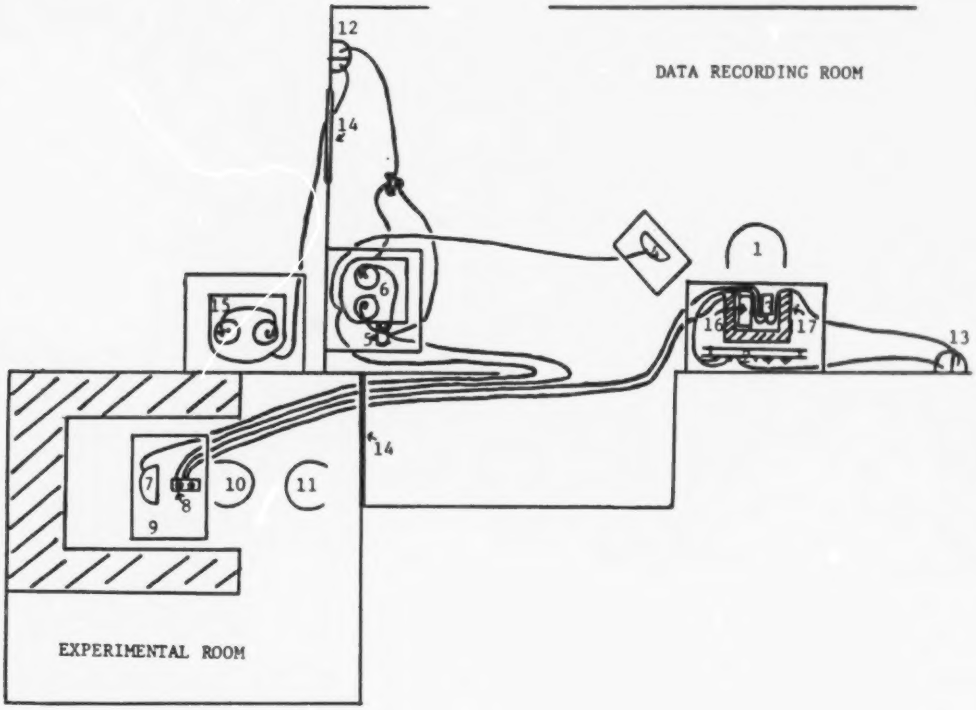
* Upward arrow indicates place within the set at which element changes.

Order: Backward

1. εb bo bi ob ↑ pε op εp pi
2. gε ig εg og gi gε ↑ ok kε
3. tε it εt to ti ↑ od εd di
4. po εp ip ↑ bo εb bi ob ib
5. og gε gi go ig εg ↑ ko ik
6. εb bi ↑ op ip po εp op pi
7. ti ot tε it to ↑ εd di do
8. ok kε ki εk ↑ go ig gε og
9. id dε ↑ ot tε it to εt it
10. pε op ip ↑ bo εb bi ob bε

APPENDIX 19

Study 3: Type of Setup for Running Study


12
DATA RECORDING ROOM
14
1
15
6
5
16
17
13
14
7
8
10
11
9
EXPERIMENTAL ROOM

(Index)

1. Experimenter's chair
2. Power supply
3. Clock
4. Second loudspeaker of taperecorder
5. Diapilot
6. Taperecorder on table
7. First loudspeaker of taperecorder
8. Response key
9. Table
10. Subject's chair
11. Blind assistant's chair
12. Socket
13. Socket
14. Door
15. Taperecorder #2 on table
16. Experimenter's response key
17. Foam-padded box

APPENDIX 20

Study 3: Instructions for Acoustic Categorization Task

The experimenter brought the subject into the Experimental Room and went through the *following routine*:

She told the subject that he would hear certain French words that meant nothing (such as ɛʃ, ʒa); rarely, he was told, it might happen that certain of these words would make you think of real French words, but he was to try to pretend he was listening to meaningless words. For example, if he was to hear ɛʃ, ʒa, ʃo, he was to try to think of ʃo as a French word, but a meaningless one, in the same way as for ɛʃ, and ʒa. He was told that the easiest way to achieve this *would be to think only at how the word was pronounced*. He was also to try not to think at how he would write them either.

The subject was also told that each word would always have a part which is ɛ, i, or o (for example ɛʃ, ʒi, oʃ). He was not to pay any attention to that part of the word but rather to concentrate only on the rest of the word. For example, for ɛʃ, he was to concentrate all his attention on the ʃ.

Two practice trials were run, with the words being uttered by the experimenter. These were:

I. ʒo - "you concentrate on what?", asked the experimenter.
II. iʃ - "you concentrate on what?", asked the experimenter.

Also, he was not to pay any attention if the word was said in a loud or soft tone of voice, or in a high or low tone, or if the tone changed. He was told that these factors were of no importance.

He was then told that he would hear a series of 8 successive words. The first two words would have something similar. Then, at a certain point after the second word, the something similar would change. The subject's task was to find when it would change.

He was told that the something similar was the following: *It was first of all a part of the words which one pronounced the same or nearly the same*. "For example", the experimenter would say, "if you hear the following words (and remember not to pay any attention to the ɛ, i, or o in the words, nor to the tone of the words): Ro Ro, what is the thing which is similar? The ‘R’. Or if you hear the following words (again without paying attention to the ɛ, i, or o, nor to the tone): Ro ro, what is the thing which is similar? The ‘R, r’. On the other hand, if your heard Ro, lo (again without paying any attention to the ɛ, i, or o, nor to the tone), there would not be anything similar, there would be the ‘R’ and the ‘l’, which are not similar." *Also, it was a part of the words with which one could construct another word, which would always have the same meaning*. The experimenter at this point took out a piece of red carton and told the subject to point to the piece when the experimenter referred to an attribute of the carton. The experimenter then said: ‘Rouge’, and then waited for a few seconds (the subject should normally point to the carton); she then said ‘louge’, and again waited for a few seconds (the subject should normally not point to the carton); she finally said ‘rouge’, and again waited for a few seconds (the subject should normally point to the carton) (all subjects performed effortlessly and perfectly on this task). The experimenter then told the subject that this was a demonstration to show how ‘R, r’, which are similar, give rise to words which mean the same, but ‘R, l’, which are not the same, do not.

Two practice trials were run. The subject's task, he was told, was to listen for the *change*: this was practiced, first by having the subject raise his hand whenever he heard the change within a given set. The practice trials were run with the words being uttered by the experimenter. These were:

I.	iR	iR	ir	il	il	il	il	il
II.	ʃo	χo	ʃo	χo	χo	ʒo	ʒo	ʒo

If performance was perfect, this was then done by asking the subject to keep the index finger of his writing hand pressed over the red button (see Appendix 19) and as soon as the word changed, he was to move it to and press the green button ('as when the streetlights change' he was told) (see Appendix 19). Then he was to keep his finger on the green button until the assistant told him that the set was over. He then was to return his finger to the red button because a new set of a repeating nonsense word followed by a change to another repeating nonsense word was ready to start.

Again, two practice trials were run with the above contrasts.

If performance was not perfect, either with the hand raising response and/or with the button press response, the above trials were repeated, but with the location of change placed in a different position, until two consecutive perfect trials were obtained. (Most subjects, however, needed only the first two examples described above).

Once both were achieved perfectly, we proceeded to the experiment-proper.

APPENDIX 21

Study 3: Instructions for Linguistic Categorization Task

The experimenter brought the subject into the Experimental Room and went through the *following routine*:

She told the subject that he would hear certain French words that meant nothing (such as ɛʃ, ʒa); rarely, he was told, it might happen that certain of these words would make you think of real French words, but he was to try to pretend he was listening to meaningless words. For example, if he was to hear ɛʃ, ʒa, ʃo, he was to try to think of ʃo as a French word, but a meaningless one, in the same way as for ɛʃ, and ʒa. He was told that the easiest way to achieve this *would be to think only at how the word was pronounced*. He was also to try not to think at how he would write them either.

The subject was also told that each word would always have a part which is ɛ, i, or o (for example ɛʃ, ʒi, oʃ). He was not to pay any attention to that part of the word but rather to concentrate only on the rest of the word. For example, for ɛʃ, he was to concentrate all his attention on the ʃ.

Two practice trials were run, with the words being uttered by the experimenter. These were:

I. ʒo - "you concentrate on what?", asked the experimenter.
II. iʃ _ "you concentrate on what?", asked the experimenter.

Also, he was not to pay any attention if the word was said in a loud or soft tone of voice, or in a high or low tone, or if the tone changed. He was told that these factors were of no importance.

He was then told that he would hear a series of eight successive words. The first two words would have something similar. Then, at a certain point after the second word, the something similar would change. The subject's task was to find when it would change.

He was told that the something similar was the following: *It was first of all a part of the words which one pronounced the same or nearly the same*. "For example", the experimenter would say, "if you hear the following words (and remember not to pay any attention to the ɛ, i, or o in the words, nor to the tone of the words): Ro iR, what is the thing which is similar? The ‘R’. Or if you hear the following words (again without paying attention to the ɛ, i, or o, nor to the tone): iR ro, what is the thing which is similar? The ‘R, r’. On the other hand, if you heard Ro il (again without paying any attention to the ɛ, i, or o, nor to the tone), there would not be anything similar, there would be the ‘R’ and the ‘l’, which are not similar."

Also it was a part of the words with which one could construct another word, which would always have the same meaning.

The experimenter at this point took out a piece of red carton and told the subject to point ot the piece when the experimenter referred to an attribute of the carton. The experimenter then said: ‘Rouge’, and then waited for a few seconds (the subject should normally point to the carton); she then said ‘rouge’, and again waited for a few seconds (the subject should normally point to the carton); she finally said ‘louge’, and again waited for a few seconds (the subject should normally not point to the carton) (all subjects performed effortlessly and perfectly on this task). The experimenter then told the subject that this was a demonstration to show how ‘R, r‘, which are similar, give rise to words which mean the same, but ‘R, l‘, which are not the same, do not.

Two practice trials were run. The subject's task, he was told, was to listen for the *change*: this was practiced, first by having the subject raise his hand whenever he heard the change within a given set. The practice trials were run with the words being uttered by the experimenter. These were:

I.	iR	Ro	ɛr	li	ol	lɛ	il	lo
II.	ʃo	ɛχ	ʃi	ɛχ	χo	ɛʒ	ʒi	oʒ

If performance was perfect, this was then done by asking the subject to keep the index finger of his writing hand pressed over the red button (see Appendix 19) and as soon as the word changed, he was to move it to and press the green button (‘as when the streetlights change‘ he was told) (see Appendix 19). Then he was to keep his finger on the green button until the assistant told him that the set was over. He then was to return his finger to the red button because a new set of a repeating nonsense word followed by a change to another repeating nonsense word was ready to start.

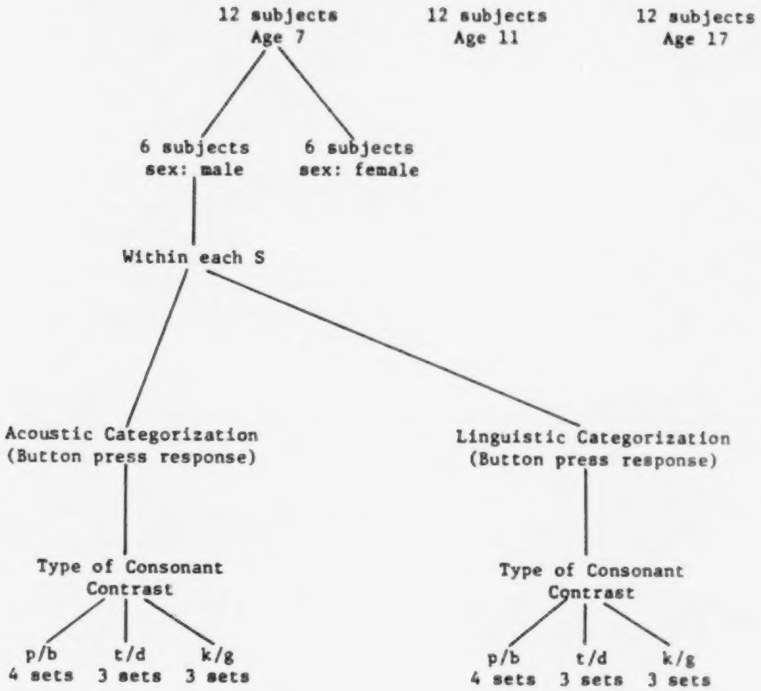
Again, two practice trials were run with the above contrasts.

If performance was not perfect, either with the hand raising response and/or with the button press response, the above trials were repeated, but with the location of change placed in a different position, until two consecutive perfect trials were obtained. (Most subjects, however, needed only the first two examples described above).

Once both were achieved perfectly, we proceeded to the experiment-proper.

APPENDIX 22

Study 3: Design of Study


12 subjects
Age 7
12 subjects
Age 11
12 subjects
Age 17
6 subjects
sex: male
6 subjects
sex: female
Within each S
Acoustic Categorization
(Button press response)
Linguistic Categorization
(Button press response)
Type of Consonant
Contrast
p/b
4 sets
t/d
3 sets
k/g
3 sets
Type of Consonant
Contrast
p/b
4 sets
t/d
3 sets
k/g
3 sets

APPENDIX 23

Table C
Study 3: Analysis of Variance Table (arc sine transformed scores)

Source	Error Term	SS	df	MS	F
A	S(AX)	14.95152	2	7.475760	12.3009**
X	S(AX)	.1620765	1	.1620765	0.2667
T	ST(AX)	15.70905	1	15.70905	45.6271**
C	SC(AX)	9.079427	2	4.539713	15.3403**
AX	S(AX)	3.646697	2	1.823348	3.0002
AT	ST(AX)	1.140919	2	.5704597	1.6569
XT	ST(AX)	.1256671	1	.1256671	0.3650
AC	SC(AX)	1.447542	4	.3618856	1.2229
XC	SC(AX)	1.074203	2	.5371016	1.8149
TC	STC(AX)	13.87421	2	6.937106	12.3677**(reg.,III)[a]
C at T1	Stthwt 3	8.7973	2	4.3986	10.2675**
C1 vs C2 at T1	Stthwt 3	8.4068	1	8.4068	19.6237**(I,IIab)
C2 vs C3 at T1	Stthwt 3	0.1071	1	0.1071	0.2500
C1 vs C3 at T1	Stthwt 3	3.9635	1	3.9635	9.2519**(I,IIab)
C at T2	Stthwt 3	14.1579	2	7.0789	16.5240**
C1 vs C2 at T2	Stthwt 3	2.4469	1	2.4469	5.7117*(I,IIa)ns(IIb)
C2 vs C3 at T2	Stthwt 3	14.0296	1	14.0296	32.7488**(I,IIab)
C1 vs C3 at T2	Stthwt 3	4.7583	1	4.7583	11.1071**(I,IIab)
S(AX)		18.23220	30	.6077401	
AXT	ST(AX)	2.766863	2	1.383432	4.0182*
AT at X1	TS(AX)	2.3221	2	1.1611	3.3724*
-A at T1 X1	Stthwt 1	3.6018	2	1.8009	3.7834*
A1 vs A2 at T1 X1	Stthwt 1	0.6622	1	0.6622	1.3912
A2 vs A3 at T1 X1	Stthwt 1	1.1616	1	1.1616	2.4403
A1 vs A3 at T1 X1	Stthwt 1	3.5778	1	3.5778	7.5164**(I)*(IIb)
-A at T2 X1	Stthwt 1	1.4625	2	0.7312	1.5361
AT at X2	TS(AX)	1.5838	2	0.7919	2.3001
AX at T1	Stthwt 1	0.1174	2	0.0587	0.1233
-A at T1	Stthwt 1	7.9074	2	3.9537	8.3061**
A1 vs A2 at T1	Stthwt 1	0.8200	1	0.8200	1.7227
A2 vs A3 at T1	Stthwt 1	3.4327	1	3.4327	7.2116**(I)*(IIb)
A1 vs A3 at T1	Stthwt 1	7.6083	1	7.6083	15.9838**(I,IIb)
-X at T1	Stthwt 1	0.0012	1	0.0012	0.0025
AX at T2	Stthwt 1	6.2942	2	3.1471	6.6116**
-A at X1 T2	Stthwt 1	1.4625	2	0.7312	1.5361
-A at X2 T2	Stthwt 1	13.0183	2	6.5091	13.6746**
A1 vs A2 at X2 T2	Stthwt 1	3.7956	1	3.7956	7.9739**(I)*(IIb)
A2 vs A3 at X2 T2	Stthwt 1	2.7420	1	2.7420	5.7605*(I)ns(IIb)
A1 vs A3 at X2 T2	Stthwt 1	12.9898	1	12.9898	27.2895**(I,IIb)
-X at A1 T2	Stthwt 1	2.9332	1	2.9332	6.1622*
-X at A2 T2	Stthwt 1	0.8099	1	0.8099	1.7015
-X at A3 T2	Stthwt 1	2.8398	1	2.8398	5.9660*
AXC	SC(AX)	2.465501	4	.6163753	2.0828
ATC	STC(AX)	1.528316	4	.3820790	0.6812
XTC	STC(AX)	2.849530	2	1.424765	2.5401
ST(AX)		10.32876	30	.3442920	

(continued on next page)

Source	Error Term	SS	df	MS	F
SC(AX)		17.75606	60	.2959343	
AXTC	STC(AX)	.9912346	4	.2478087	0.4418
STC(AX)		33.65418	60	.5609030	
Stthwt 1			56	0.4760	
Stthwt 3			110	0.4284	

Note. A = Age Factor: levels: 7 (A1), 11 (A2), 17 (A3);

X = Sex Factor: levels: female (X1), male (X2);

T = Task: levels: Acoustic Categorization (T1), Linguistic Categorization (T2);

C = Contrast: levels: p/b (C1), t/d (C2), k/g (C3).

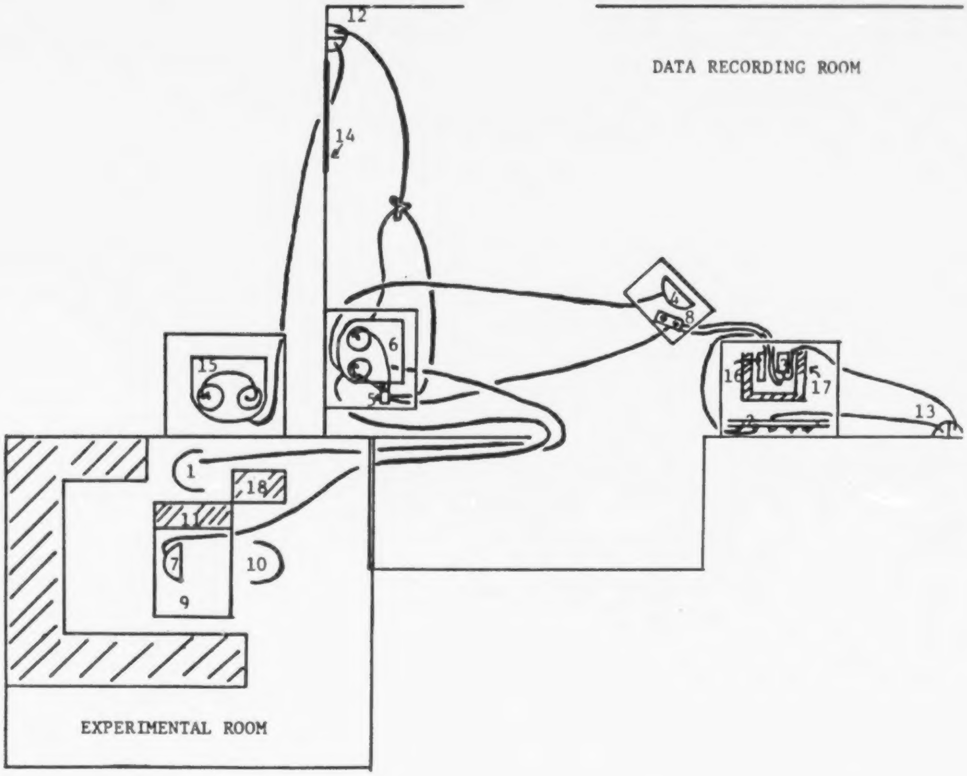
* $p < .05$.

** $p < .01$.

[a] (I): per comparison error rate set at $p < .05$, or $p < .01$; (IIa): interpolated degrees of freedom - more precise than (IIb) if the latter is borderline and (IIb) is ultraconservative; (IIb): overall α (that is, over all possible comparisons) set at $p < .05$, or $p < .01$ (Tukey test); (III): conservative degrees of freedom for repeated measures designs (Greenhouse & Geiser procedure).

APPENDIX 24

Study 4: Type of Setup for Running Study



12
DATA RECORDING ROOM
14
4
8
6
5
15
16
3
17
2
13
1
18
11
7
10
9
EXPERIMENTAL ROOM

(Index)

1. Experimenter's chair
2. Power supply
3. Clock
4. Second loudspeaker of taperecorder
5. Diapilot
6. Taperecorder on table
7. First loudspeaker of taperecorder
8. Response key
9. Table
10. Subject's chair
11. Cardboard box with 1-way view slit: from Experimenter to Subject's writing paper on table
12. Socket
13. Socket
14. Door
15. Taperecorder #2 on table
16. Experimenter's response key
17. Foam-padded box
18. 4 feet high cardboard box

APPENDIX 25

Study 4: Instructions for the Linguistic Categorization Task With the Repetition Response

The experimenter brought the subject into the Experimental Room and went through the *following routine:*

She told the subject that he would hear certain French words that meant nothing (such as ɛʃ, ʒa); rarely, he was told, it might happen that certain of these words would make you think of real French words, but he was to try to pretend he was listening to meaningless words. For example, if he was to hear ɛʃ, ʒa, ʃo, he was to try to think of ʃo as a French word, but a meaningless one, in the same way as for ɛʃ, and ʒa. He was told that the easiest way to achieve this *would be to think only at how the word was pronounced*. He was also to try not to think at how he would write them either.

The subject was also told that he would hear a series of eight successive words. The first two words would have something similar. Then, at a certain point after the second word, the something similar would change.

He was also told that each word would always have a part which is ɛ, i, or o (for example ɛʃ, ʒi, oʃ). That part of the word was not important. For example for ɛʃ, the important part was the ʃ.

Two practice trials were run, with the words being uttered by the experimenter. These were:

I. ʒo - "what is the important part?", asked the experimenter.
II. iʃ - "what is the important part?", asked the experimenter.

Also, he was told that it was not important if the word was said in a loud or soft tone of voice, or in a high or low tone, or if the tone changed.

He was told that the something similar was the following: It was first of all a part of the words which one pronounced the same or nearly the same. "For example", the experimenter would say, "if you hear the following words (and remember that the ɛ, i, or o in the words is not important, nor the tone of the words): Ro iR, what is the thing which is similar? The 'R'. Or if you hear the following words (again the ɛ, i, or o, is not important nor the tone): iR ro, what is the thing which is similar? The 'R, r'. On the other hand, if you hear Ro il (again the ɛ, i, or o, is not important nor the tone), there would not be anything similar, there would be the 'R' and the 'l', which are not similar."

Also it was a part of the words with which one could construct another word, which would always have the same meaning.

The experimenter at this point took out a piece of red carton and told the subject to point to the piece when the experimenter referred to an attribute of the carton. The experimenter then said: 'louge', and then waited for a few seconds (the subject should normally not point to the carton); she then said 'rouge', and again waited for a few seconds (the subject should normally point to the carton); she finally said 'Rouge', and then waited for a few seconds (the subject should normally point to the carton) (all subjects performed effortlessly and perfectly on this task). The experimenter then told the subject that this was a demonstration to show how 'R, r', which are similar, give rise to words which mean the same, but 'R, l', which are not the same, do not.

Two practice trials were run. The subject had to raise his hand whenever he heard the change within a given set. The practice trials were run with the words being uttered by the experimenter. These were:

I. iR Ro εr li ol lε il lo
II. ʃo εχ ʃi εχ χo εʒ ʒi oʒ

If performance was not perfect, the above trials were repeated, but with the location of change placed in a different position, until two consecutive perfect trials were obtained. (Most subjects, however, needed only the first two examples described above).

The subject was then told that what he had to do this time, was to repeat the word, every word, as soon as he heard it. For example, he was told, if he were to hear ʃo, what was he to say?

Two practice trials were run, with the words being uttered by the experimenter. These were:

I. ʃo
II. εʒ

If performance was not perfect, the above trials were repeated, with other nonsense words (such as Ro, li, oʒ, etc.) until two consecutive perfect trials were obtained.

APPENDIX 26

Study 4: Instructions for the Linguistic Categorization Task With the Spelling Response

The experimenter brought the subject into the Experimental Room and went through the *following routine:*

She told the subject that he would hear certain French words that meant nothing (such as ɛʃ, ʒa); rarely, he was told, it might happen that certain of these words would make you think of real French words, but he was to try to pretend he was listening to meaningless words. For example, if he was to hear ɛʃ, ʒa, ʃo, he was to try to think of ʃo as a French word, but a meaningless one, in the same way as for ɛʃ, and ʒa. He was told that the easiest way to achieve this *would be to think only at how the word was pronounced.*

The subject was also told that he would hear a series of eight successive words. The first two words would have something similar. Then, at a certain point after the second word, the something similar would change.

He was also told that each word would always have a part which is ɛ, i, or o (for example ɛʃ, ʒi, oʃ). That part of the word was not important. For example for ɛʃ, the important part was the ʃ.

Two practice trials were run, with the words being uttered by the experimenter. These were:

I. ʒo - "what is the important part?", asked the experimenter.
II. iʃ - "what is the important part?", asked the experimenter.

Also, he was told that it was not important if the word was said in a loud or soft tone of voice, or in a high or low tone, or if the tone changed.

He was told that the something similar was the following: It was first of all a part of the words which one pronounced the same or nearly the same. "For example", the experimenter would say, "if you hear the following words (and remember that the ɛ, i, or o in the words is not important, nor the tone of the words): Ro iR, what is the thing which is similar? The 'R'. Or if you hear the following words (again the ɛ, i, or o, is not important nor the tone): iR ro, what is the thing which is similar? The 'R, r'. On the other hand, if you hear Ro il (again the ɛ, i, or o, is not important, nor the tone), there would not be anything similar, there would be the 'R' and the 'l', which are not similar."

Also it was a part of the words with which one could construct another word, which would always have the same meaning.

The experimenter at this point took out a piece of red carton and told the subject to point to the piece when the experimenter referred to an attribute of the carton. The experimenter then said: 'rouge', and then waited for a few seconds (the subject should normally point to the carton); she then said 'louge', and again waited for a few seconds (the subject should normally not point to the carton); she finally said 'Rouge', and then waited for a few seconds (the subject should normally point to the carton) (all subjects performed effortlessly and perfectly on this task). The experimenter then told the subject that this was a demonstration to show how 'R, r', which are similar, give rise to words which mean the same, but 'R, l', which are not the same, do not.

Two practice trials were run. The subject had to raise his hand whenever he heard the change within a given set. The practice trials were run with the words being uttered by the experimenter. These were:

I. iR Ro εr li ol lε il lo
II. ʃo εχ ʃi εχ χo εʒ ʒi oʒ

If performance was not perfect, the above trials were repeated, but with the location of change placed in a different position, until two consecutive perfect trials were obtained. (Most subjects, however, needed only the first two examples described above).

The subject was then told that what he had to do this time, was to write down the word, every word, as soon as he heard it. He was to think about how he would pronounce it, and then write it down. He was to write it down as soon as he had heard it. He was told that it didn't matter if he was not sure of himself: he was to write what he thought, that was all. He was never to return and correct himself, once he had written the word. For example, he was told, if he were to hear ʃo, what was he to write?

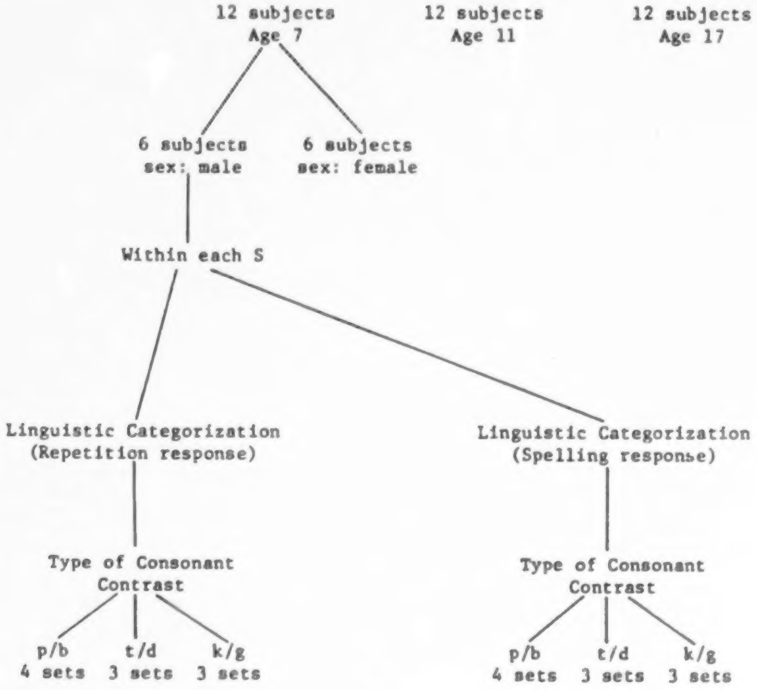
Two practice trials were run, with the words being uttered by the experimenter. These were:

I. ʃo
II. εʒ

If performance was not perfect, the above trials were repeated, with other nonsense words (such as Ro, li, oʒ, etc.) until two consecutive perfect trials were obtained.

APPENDIX 27

Study 4: Design of Study


12 subjects
Age 7
12 subjects
Age 11
12 subjects
Age 17
6 subjects
sex: male
6 subjects
sex: female
Within each S
Linguistic Categorization
(Repetition response)
Linguistic Categorization
(Spelling response)
Type of Consonant
Contrast
p/b
4 sets
t/d
3 sets
k/g
3 sets
Type of Consonant
Contrast
p/b
4 sets
t/d
3 sets
k/g
3 sets

APPENDIX 28

Table D
Study 4: Analysis of Variance Table (arc sine transformed scores)

Source	Error Term	SS	df	MS	F
A	S(AX)	4.748928	2	2.374464	2.1954
X	S(AX)	3.544413	1	3.544413	3.2771
T	ST(AX)	3.901248	2	1.950624	5.5976*(III)^a
C	SC(AX)	46.75988	2	23.37993	31.0476**(III)
AX	S(AX)	16.47307	2	8.236540	7.6153**
.X at A1	S(AX)	13.5448	1	13.5448	12.5232**
X at A2	S(AX)	2.4870	1	2.4870	2.2994
X at A3	S(AX)	3.9859	1	3.9859	3.6853
.A at X1	S(AX)	3.9701	2	1.9851	1.8354
A at X2	S(AX)	17.2480	2	8.6240	7.9736**
A1 vs A2 at X2	S(AX)	5.8690	1	5.8690	5.4263*(I)ns(II)
A2 vs A3 at X2	S(AX)	2.9261	1	2.9261	2.7054ns(I)ns(II)
A1 vs A3 at X2	S(AX)	17.0831	1	17.0831	15.7947**(I)**(II)
AT	ST(AX)	4.358368	4	1.089592	3.1267
XT	ST(AX)	.5192776	2	.2596388	0.7451
AC	SC(AX)	4.547439	4	1.136859	1.5097
XC	SC(AX)	.5451431	2	.2725715	0.3620
TC	STC(AX)	2.478675	4	.6196689	1.5542
S(AX)		32.44725	30	1.081575	
AXT	ST(AX)	.7943227	4	.1985806	0.5699
AXC	SC(AX)	6.786792	4	1.696697	2.2531
ATC	STC(AX)	1.911922	8	.2389903	0.5994
XTC	STC(AX)	2.696358	4	.6740895	1.6907
ST(AX)		20.90850	60	.3484751	
SC(AX)		45.18212	60	.7530354	
AXTC	STC(AX)	2.326167	8	.2907710	0.7293
STC(AX)		47.84525	120	.3987104	

Note. A — Age Factor: levels: 7 (A1), 11 (A2), 17 (A3);

X — Sex Factor: levels: female (X1), male (X2);

T — Task: levels: Linguistic Categorization, Button Press response (T1), Linguistic Categorization, Repetition response (T2), Linguistic Categorization, Spelling response (T3);

C — Contrast: levels: p/b (C1), t/d (C2), k/g (C3).

* $p < .05$.

** $p < .01$.

^{a}(I): per comparison error rate set at $p < .05$, or $p < .01$; (II): overall α (that is, over all possible comparisons) set at $p < .05$, or $p < .01$ (Tukey test); (III): conservative degrees of freedom for repeated measures designs (Greenhouse & Geiser procedure).

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APPENDIX 29

Table E

Study 4: Additional Analyses of Repetition Data: Analysis of Variance Table (arc sine transformed scores)

Source	Error Term	SS	df	MS	F
A	S(AX)	.3710150	2	.1855075	0.2902
X	S(AX)	.8580097	1	.8580097	1.3422
P	SP(AX)	20.36699	1	20.36699	49.8153**(reg)**(III)[a]
C	SC(AX)	64.87059	2	32.43529	36.9047**(reg)**(III)
C1 vs C2	SC(AX)	20.9949	1	20.9949	23.8879**(I,II)
C2 vs C3	SC(AX)	64.4392	1	64.4392	73.3185**(I,II)
C1 vs C3	SC(AX)	11.8707	1	11.8707	13.5064**(I,II)
AX	S(AX)	10.98745	2	5.493723	8.5941
AP	SP(AX)	.7791183	2	.3895591	0.9528
XP	SP(AX)	.5076979D-02	1	.5076979D-02	0.0124
AC	SC(AX)	3.020822	4	.7552054	0.8593
XC	SC(AX)	.2745838	2	.1372919	0.1562
PC	SPC(AX)	.5750973	2	.2875486	0.5482
S(AX)		19.17740	30	.6392469	
AXP	SP(AX)	1.172925	2	.5864629	1.4344
AXC	SC(AX)	11.39080	4	2.847699	3.2401
APC	SPC(AX)	5.917001	4	1.479250	2.8199
XPC	SPC(AX)	.4485878	2	.2242939	0.4276
SP(AX)		12.26550	30	.4088500	
SC(AX)		52.73365	60	.8788941	
AXPC	SPC(AX)	1.865382	4	.4663457	0.8890
SPC(AX)		31.47429	60	.5245716	

Note. A — Age Factor: levels: 7 (A1), 11 (A2), 17 (A3);

X — Sex Factor: levels: female (X1), male (X2);

P — Part: levels: Stimuli found in the Acoustic and Linguistic Categorization Tasks of Study 3 (P1), Stimuli found only in the Linguistic Categorization Task of Study 3 (P2);

C — Contrast: levels: p/b (C1), t/d (C2), k/g (C3).

** *p* < .01.

[a] (I): per comparison error rate set at p < .05, or p < .01; (II): overall α (that is, over all possible comparisons) set at p < .05, or p < .01 (Tukey test); (III): conservative degrees of freedom for repeated measures designs (Greenhouse & Geiser procedure).

APPENDIX 30

Experimenter's Small Study of Montreal French: List of 4 to 5 Word Phrases or Sentences Selected at Random From "La Presse" Newspaper

1. On verra plus tard
2. La banque d'épargne veut
3. La vente d'AWAC à l'Arabie Séoudite
4. Et n'allez surtout pas croire
5. des dizaines de milliers d'usagers des postes
6. je vous soulignais récemment
7. mais il refuse de céder sur les
8. En matinée
9. à la population depuis un an.
10. procureur en chef adjoint
11. une enquête préliminaire tenue devant le juge
12. peut être effectué dans tous les secteurs
13. de milliers de Vietnamiens ont décidé
14. un mécanisme pour les aider.
15. reconsidérer l'évaluation des maisons touchées.
16. sous les ordres du sergent.
17. Le Rhône, le Sud-ouest, le Languedoc
18. 4 dimensions, un seul bas prix
19. de l'Autoroute de Laurentides
20. à l'image de votre personnalité
21. pour dire la vérité
22. le Café Nelligan, boul. Dorchester
23 en dépit d'une scénographie
24. Comment déceler les problèmes.
25. aux Laval, Versailles et Greenfield.
26. Cette politique étant nouvelle
27. impute principalement la chute
28. une seconde propriété
29. pour faire en sorte que
30. ont changé le cours
31. le 16 novembre 1981
32. Murdochville - Dans un premier train.
33. Indices à la Bourse de Montréal
34. sont économiques et non constitutionnels
35. fabricant de rideaux de douche
36. si fulgurant que j'en restai pantois.
37. Ste-Adèle, maison suisse meublée.
38. la Diffusion des arts carcéraux
39. de grandes dimensions, aux prix élevés
40. par un "effondrement conjonctuel"
41. de certains marchés
42. Il s'agirait alors de ne pas y avoir
43. M. Pierre de Bané
44. à mieux déterminer l'ampleur
45. une augmentation du taux
46. et des services de bureau.
47. Elles sont rachetables le 1er octobre 1984.
48. par l'administration américaine
49. Envoyer curriculum vitae à
50. me fit frémir.
51. leur orientation est bien différente
52. de différents milieux dont plusieurs
53. par la mise sur pied
54. à l'aide d'un document visuel.
55. j'avais posé une condition supplémentaire.
56. sa Célébration du design.
57. chaque repas Chez la Mère Tucker
58. contre son challenger Victor Kortchnoi
59. M. Bora Laskin, qui l'a interrompu
60. Installez-vous à votre aise.
61. des championnats du monde
62. Daniel Fortin a constaté
63. des vols par effraction
64. Viandes froides.
65. nous préparons notre propre budget
66. le 25 décembre approche rapidement
67. à partir des plans d'ensemble
68. Fenêtres coulissantes Thermos.
69. Le candidat possédant un diplôme
70. secteur centre ville
71. Assurance, toutes les grandeurs.
72. plomberie, électricité
73. une somme de $10 non remboursable.
74. peut être rejetée si la Ville
75. informé de la demande
76. Les Expos tiennent bon.
77. qu'il constituait le point égalisateur
78. aussi serrée au championnat
79. deux autres coureurs sur les buts.
80. le releveur droitier acquis des Mets
81. jusqu'au moment où Jacques Laperrière décida
82. Les Alouettes méritent tous les qualificatifs
83. même surface artificielle
84. le Forbes Field ressemblait à un enclos.
85. au Stade Olympique
86. non moins prestigieux Babe Ruth.
87. Un arrêt in-extremis du gardien
88. Nelligan blanc.
89. le service des loisirs de Longueuil
90. Université du Québec à Montréal.
91. Le Groupe Québec International.
92. à la suite de sa nette victoire
93. a fort apprécié le changement
94. à Santa Clara voici trois mois déjà
95. le droit de participer au championnat
96. Si tout fonctionne bien cette saison
97. Je sais que je tiens ma dernière chance.
98. Six arbitres par match.
99. avec Michel Charbonneau
100. les chances avec deux points

APPENDIX 31

Experimenter's Small Study of Montreal French: List of Single Words Extracted From Phrases or Sentences in Appendix 30

1. verra
2. banque
3. l'Arabie
4. croire
5. milliers
6. récemment
7. sur
8. En
9. depuis
10. adjoint
11. devant
12. effectué
13. ont
14. aider
15. l'évaluation
16. ordres
17. Sud-ouest
18. bas
19. l'Autoroute
20. personnalité
21. dire
22. Dorchester
23. dépit
24. déceler
25. Versailles
26. politique
27. principalement
28. seconde
29. pour
30. changé
31. novembre
32. Murdochville
33. Montréal
34. constitutionnels
35. douche
36. fulgurant
37. maison
38. Diffusion
39. dimensions
40. effondrement
41. certains
42. s'agirait
43. Pierre
44. mieux
45. augmentation
46. des
47. sont
48. américaine
49. curriculum
50. frémir
51. orientation
52. dont
53. mise
54. l'aide
55. j'avais
56. design
57. repas
58. Kortchnoi
59. qui
60. Installez-vous
61. monde
62. constaté
63. vols
64. froides
65. préparons
66. approche
67. plans
68. coulissantes
69. diplôme
70. secteur
71. toutes
72. électricité
73. somme
74. peut
75. de
76. tiennent
77. constituait
78. championnat
79. coureurs
80. des
81. moment
82. méritent
83. même
84. ressemblait
85. au
86. prestigieux
87. in-extremis
88. Nelligan
89. Longueuil
90. Université
91. Québec
92. sa
93. changement
94. voici
95. droit
96. saison
97. sais
98. match
99. Charbonneau
100. avec

APPENDIX 32

Experimenter's Small Study of Montreal French: Phonetic and Phonemic Transcription of Appendix 31 Words (Strict Phonemic Approach)

	Phonetic transcription[a]	Phonemic transcription
1.	vɛ/ʀɑ	vɛ/ʀa
2.	bɑ̃k	bɑ̃k
3.	la/ʀa/bi	la/ʀa/bi
4.	kʀwɑːʀ	kʀwaːʀ
5.	mi/lje	mi/lje
6.	ʀe/sa/mɑ̃	ʀe/sa/mɑ̃
7.	syʁ	syʀ
8.	ɑ̃	ɑ̃
9.	də/pɥi	də/pɥi
10.	ad/ʒwɛ̃	ad/ʒwɛ̃
11.	də/vɑ̃	də/vɑ̃
12.	ɛ/fɛk/tɥe	ɛ/fɛk/tɥe
13.	ɔ̃	ɔ̃
14.	zɛ/de (ou ze/de)	zɛ/de
15.	le/va/lɥa/sjɔ̃	le/va/lɥa/sjɔ̃
16.	zɔʀd	zɔʀdʀ
17.	syd/wɛst	syd/wɛst
18.	bɑ	bɑ
19.	lo/to/ʀʊt	lo/to/ʀut
20.	pɛʀ/sɔ/na/li/te	pɛʀ/sɔ/na/li/te
21.	d$_z$iʀ	diʀ
22.	dɔʀ/tʃɛs/təʀ	dɔʀt/ʃɛs/tɑʀ
23.	de/pi	de/pi
24.	de/sle	de/sle

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[a] (Notation used: for /p/, /b/, /t/, /d/, /k/, /g/, with ɛ, i, o, either as CV or as VC, concordant with IPA notation, phonetically)

	Phonetic transcription	Phonemic transcription
25.	vɛʀ/sɑj	vɛʀ/saij
26.	pɔ/li/t̪ɪk	pɔ/li/tik
27.	pʀɛ̃/si/pal/mɑ̃	pʀɛ̃/si/pal/mɑ̃
28.	sə/gɔ̃d	sə/gɔ̃d
29.	puʀ	puʀ
30.	ʃɑ̃/ʒe	ʃɑ̃/ʒe
31.	nɔ/vɑ̃b	nɔ/vɑ̃bʀ
32.	mœʀ/dɔk/vɪl	mœʀ/dɔk/vil
33.	mɔ̃/ʀe/al	mɔ̃/ʀe/al
34.	kɔ̃s/t̪i̥/t̪y̥/sjɔ/nɛl	kɔ̃s/ti/ty/sjɔ/nɛl
35.	dʊʃ	duʃ
36.	fyl/gy/ʀɑ̃	fyl/gy/ʀɑ̃
37.	mɛ/zɔ̃	mɛ/zɔ̃
38.	d$_z$i/fy/zjɔ̃	di/fy/zjɔ̃
39.	d$_z$i/mɑ̃/sjɔ̃	di/mɑ̃/sjɔ̃
40.	ɛ/fɔ̃/dʀə/mɑ̃	ɛ/fɔ̃/dʀə/mɑ̃
41.	sɛʀ/tɛ̃	sɛʀ/tɛ̃
42.	sa/ʒɪ/ʀɛ	sa/ʒi/ʀɛ
43.	pjɛʀ	pjɛʀ
44.	mjø	mjø
45.	ɔg/mɑ̃/ta/sjɔ̃	ɔg/mɑ̃/ta/sjɔ̃
46.	de	de
47.	sɔ̃	sɔ̃
48.	a/me/ʀi/kɛn	a/me/ʀi/kɛn
49.	ky/ʀi/ky/lum	ky/ʀi/ky/lum
50.	fʀe/miʀ	fʀe/miʀ
51.	ɔ/ʀjɑ̃/ta/sjɔ̃	ɔ/ʀjɑ̃/ta/sjɔ̃
52.	dɔ̃	dɔ̃
53.	miz	miz
54.	lɛ:d	lɛ:d
55.	ʒa/vɛ	ʒa/vɛ
56.	di/zaɪ̯ŋ	di/zaɪ̯ŋ

	Phonetic transcription	Phonemic transcription
57.	ʀə/pɑ	ʀə/pɑ
58.	kɔʀtʃ/nɔj	kɔʀtʃ/nɔj
59.	ki	ki
60.	ɛ̃s/ta/le/vu	ɛ̃s/ta/le/vu
61.	mɔ̃:d	mɔ̃:d
62.	kɔ̃s/ta/te	kɔ̃s/ta/te
63.	vɔl	vɔl
64.	fʀwad	fʀwad
65.	pʀe/pa/ʀɔ̃	pʀe/pa/ʀɔ̃
66.	a/pʀɔʃ	a/pʀɔʃ
67.	plɑ̃	plɑ̃
68.	ku/li/sɑ̃:t	ku/li/sɑ̃:t
69.	dʑi/plo:m	di/plo:m
70.	sɛk/tœʀ	sɛk/tœʀ
71.	tʊt	tut
72.	e/lɛk/tʀis/te	e/lɛk/tʀi/si/te
73.	sɔm	sɔm
74.	pø	pø
75.	də ou dla	də ou dla
76.	t̡jɛn	tjɛn
77.	kɔ̃s/t̡i/t̡ɥɛ	kɔ̃s/ti/tɥe
78.	ʃɑ̃/pjɔ/nɑ	ʃɑ̃/pjɔ/nɑ
79.	ku/ʀœʀ	ku/lœʀ
80.	de	de
81.	mo/mɑ̃	mɔ/mɑ̃
82.	me/ʀɪt	me/ʀit
83.	mɛ:m	mɛ:m
84.	ʀɛ/sɑ̃/blɛ	ʀə/sɑ̃/ble
85.	o	o
86.	pʀɛs/t̡i/ʒiø	pʀɛs/ti/ʒiø
87.	ɪ/nɛks/tʀe/mɪs	ɪ/nɛks/tʀe/mis
88.	nɛ/li/gən	nɛ/li/gən

	Phonetic transcription	Phonemic transcription
89.	lɔ̃/gœj	lɔ̃/gœj
90.	y/ni/vɛʀ/sj/te	y/ni/vɛʀ/si/te
91.	ke/bɛk	ke/bɛk
92.	sa	sa
93.	ʃɑ̃ʒ/mɑ̃	ʃɑ̃ʒ/mɑ̃
94.	vwa/si	vwa/si
95.	dʀwa	dʀwa
96.	sɛ/zɔ̃	sɛ/zɔ̃
97.	se	se
98.	matʃ	matʃ
99.	ʃaʀ/bɔ/no	ʃaʀ/bɔ/no
100.	a/vɛk	a/vɛk

APPENDIX 33

Experimenter's Small Study of Montreal English: List of 4 to 5 Word Phrases or Sentences Selected at Random From "The Gazette" Newspaper

1. "Minute Ottawa" ad campaign
2. At the same time, Serge Joyal,
3. Courtois told campaign officials
4. Centraide is seeking $15.4 million
5. The creation of the new agency
6. slated to increase dramatically during the next
7. We buy for highest cash prices.
8. third-floor room when the fire broke out.
9. which the city says would pose
10. Thermal heating pad is built
11. exceeded $7 million.
12. double pedestal table
13. snowdrifts halfway up the windows
14. the woman's husband, has testified
15. that remaining dissidents would have to leave
16. Gratton was one of those who
17. will have to live afterwards with the consequences
18. that many saw in Trudeau's press conference
19. Printers yesterday bowed to threats by publisher
20. the borders with Chad in order
21. we will always oppose armaments both East and West
22. Riots can break out in the next
23. and found the accusations of falling debris
24. Datsun 210 is durable, reliable and downright
25. is somewhat taken aback by the attitude
26. in the American League East.
27. the bases when he sliced a triple into the
28. that our game is as good or better
29. of the Year who scored 23 regular-season
30. This was just 21-year-old Lamarre's
31. not have specific information on the
32. "Jim", said Cromartie, "I can go".
33. Executive vice-president Brian
34. Raiders start WR Morris Bradshaw,
35. Jorg and Erkhart Diesch to move
36. Ile Bizard, split level,
37. Weekdays, 932-2293. Evenings,
38. Large, quiet, 4½, heated
39. indoor pool and garage
40. Also small 2½ in half basement only.
41. with eating area, separate dining room
42. The Bay Registered 3.00 to 5.00
43. After tripling home two runs
44. Tigers out of a tie for the lead
45. Cincinnati. Nolan Ryan fired a
46. That may tell you a lot
47. Quebec Nordiques, who spirited
48. to tell what will happen.
49. 5000 long-playing records
50. numerical order from the valid
51. and she has three major films either
52. , both shot in French.
53. I saw Animal House too many times.
54. McNichol plays the teen-age daughter
55. of deciding the divisional race
56. a timely report about the curious
57. saw him at his best as he voluptuously
58. support from the Quebec government.
59. with bigger ballet companies.
60. Jacklin Williams as his mother Peggy
61. There were no girls.
62. program designed to introduce young
63. a pun in which "the 20th of
64. the veal Zingara was a little better
65. midnight. Fully licensed.
66. who is half-English and half-French
67. to try several different wines
68. London, Austria and Montreal
69. that one of the charming waiters
70. about a quarter of a million pairs
71. to bolster attendance
72. Whiz bang with Tommy Sands.
73. and only for a moment at over-confident boys.
74. but keep putting it off.
75. of being safe is realized
76. that none of Drummond McCall's directors.
77. got advance notice of yesterday's announcement
78. a fraction below last week's
79. together with interest coupons
80. The underlying problems which
81. the cost of research and development
82. The final purchase price will be determined
83. Communications regulators have denied
84. and move its head office to
85. million contracts, compared with
86. that Asbestos takeover is near
87. very running of the oil industry
88. becoming economically feasible
89. Initial salary commensurate with experience.
90. with members of the multidisciplinary treatment team.
91. expand the operation to other
92. and calculate flight data
93. all-new passenger airplane in a decade.
94. there would be no squeese
95. unguard one of the minor suits.
96. Kitten female, grey and black
97. at the Rawdon Anglican Church.
98. house plants. Rather than
99. Cote St. Antoine Road
100. Celebration at the Resurrection.

APPENDIX 34

Experimenter's Small Study of Montreal English: List of Single Words Extracted From Phrases or Sentences in Appendix 33

1. Ottawa
2. time
3. told
4. is
5. creation
6. dramatically
7. highest
8. fire
9. says
10. heating
11. million
12. pedestal
13. windows
14. has
15. would
16. one
17. with
18. many
19. yesterday
20. in
21. both
22. break
23. the
24. durable
25. somewhat
26. League
27. sliced
28. good
29. scored
30. This
31. specific
32. Cromartie
33. president
34. start
35. Erkhart
36. split
37. Weekdays
38. heated
39. garage
40. small
41. separate
42. Registered
43. home
44. tie
45. Cincinnati
46. may
47. who
48. happen
49. records
50. order
51. and
52. shot
53. too
54. age
55. divisional
56. report
57. voluptuously
58. Quebec
59. ballet
60. as
61. There
62. to
63. which
64. little
65. licensed
66. French
67. different
68. Montreal
69. charming
70. pairs
71. attendance
72. bang
73. confident
74. putting
75. realized
76. McCall's
77. yesterday's
78. last
79. interest
80. underlying
81. of
82. purchase
83. Communications
84. office
85. compared
86. Asbestos
87. oil
88. feasible
89. commensurate
90. multidisciplinary
91. operation
92. flight
93. airplane
94. there
95. unguard
96. Kitten
97. Rawdon
98. Rather
99. Cote
100. Celebration

APPENDIX 35

Experimenter's Small Study of Montreal English: Phonetic and Phonemic Transcription of Appendix 34 Words (Strict Phonemic Approach)

	Phonetic transcription[a]	Phonemic transcription
1.	ɑ:/ɾ̬ə/wɑ	ɑ/tə/wɑ
2.	tʰaym	taym
3.	tʰowɫd°	told
4.	Iz̥	Iz
5.	kʰɹI/yey/šən	krI/e/šən
6.	dɹə/mæ:/ɾ̬ə/kli	drə/mæ/təkli
7.	hay/əst	hayəst
8.	fay/əɹ	fay/ər
9.	sɛz	sɛz
10.	hi:/ɾ̬Iŋ	hi/tIŋ
11.	mIl/yən	mIl/yən
12.	pʰɛ/ɾəs/təl̩	pɛ/dəs/təl
13.	wIn/dowz̥	wIn/doz
14.	hæz̥	hæz
15.	wɝd	wɝd
16.	wʌn	wən
17.	wIθ	wIθ
18.	mɛ/ni	mɛ/ni
19.	yɛs/təɹ/dey	yɛs/tər/de
20.	In	In
21.	bowθ	boθ
22.	bɹeyk	brek
23.	ðiy	ði
24.	dyʊ/ɹə/bəɫ	dyʊ/rə/bəl

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[a] (Notation used: for /p/, /b/, /t/, /d/, /k/, /g/, with ɛ, i, o, either as CV or as VC, concordant with IPA notation, phonetically)

	Phonetic transcription	Phonemic transcription
25.	sʌm/wət°	səm/wət
26.	liːg	lig
27.	slayst	slayst
28.	gʊd	gʊd
29.	skɔːɹd°	skɔrd
30.	ðIs	ðIs
31.	spə/sI/fIk	spə/sI/fIk
32.	kʰɹə/mɑːɹ/ti	krə/mɑr/ti
33.	pʰɹɛ/zə/ɾənt°	prɛ/zə/dənt
34.	stɑːɹt°	stɑrt
35.	ɛːɹk/hɑɹt°	ɛrk/hɑrt
36.	splIt	splIt
37.	wiːk°/deyz	wik/dez
38.	hiː/ɾ̥əd	hi/təd
39.	gə/ɹæːž	gə/ræž
40.	smɑːɫ	smɑl
41.	sɛ/pɹət°	sɛp/rət
42.	ɹɛ/ǰə/stəɹd°	rɛ/ǰə/stərd
43.	howm	hom
44.	tʰay	tay
45.	sIn/sə/næː/ɾ̥i	sIn/sə/næ/ti
46.	mey	me
47.	hu	hu
48.	hæː/pən	hæ/pən
49.	ɹɛ/kəɹdz̥	rɛ/kərdz
50.	ɔːɹ/ɾəɹ	or/dər
51.	æn	æn
52.	šɑːt	šɑt
53.	tʰu	tu
54.	eyǰ	eǰ
55.	də/vI/žə/nəɫ	də/vI/žə/nəl
56.	ɹə/pʰɔːɹɾ	rə/pɔrt

	Phonetic transcription	Phonemic transcription
57.	və/lʌp°/ču/wəs/li	və/ləp/ču/əs/li
58.	kʰwə/ƀɛk°	kwə/ƀɛk
59.	bæ:/ley	bæ/le
60.	æz	æz
61.	ðɛɹ	ðɛr
62.	tʰuw	tu
63.	wIč	wIč
64.	lI/ɾəɫ	lI/təl
65.	lay/sənst	lay/sənst
66.	fɹɛnš	frɛnš
67.	dIf/ɹənt°	dIf/rənt
68.	mʌn/tʰɹi/yɑ:ɫ	mən/triɑl
69.	čɑ:ɹ/mIŋ	čar/mIŋ
70.	pʰɛ:ɹz	pɛrz
71.	ə/tʰɛn/dəns	ə/tɛn/dəns
72.	bæŋ	bæŋ
73.	kʰɑ:n/fə/ɾənt°	kɑn/fə/dənt
74.	pʰʊ/ɾIŋ	pʊ/tIŋ
75.	ɹi/yə/layz̥d	ri/ə/layzd
76.	mə/kʰɑ:ɫz	mə/kɑlz
77.	yɛs/təɹ/deyz	yɛs/tər/deyz
78.	læst	læst
79.	In/tɹəst°	In/trəst
80.	ʌn/dəɹ/lay/Iŋ	ən/dər/lay/Iŋ
81.	əv	əv
82.	pʰə:ɹ/čəs	pər/čəs
83.	kʰə/myu/nə/key/šənz	kə/myu/nə/ke/šənz
84.	ɑ:/fəs	ɑ/fəs
85.	kʰəm/pʰɛ:ɹd	kəm/pɛrd
86.	əs/bɛs/təs	əs/bɛs/təs
87.	ɔyl	ɔyl
88.	fi:/zə/bəɫ	fi/zə/bəl

	Phonetic transcription	Phonemic transcription
89.	kʰə/mɛn/šə/ɻət°	kə/mɛn/šə/rət
90.	mʌɫ/ti/dI/sI̥/plə/nɛ/ɻi	məl/ti/dI/sI/plə/nɛ/ri
91.	ɑ/pə/ɻey/šən	ɑ/pə/re/šən
92.	flayt°	flayt
93.	ɛ:ɻ/pʰleyn	ɛr/plen
94.	ðɛɻ	ðɛr
95.	ʌn/ga:ɻd	əngard
96.	kʰI/tn̩	kI/tən
97.	ɻɑ:/dn	rɑ/dən
98.	ɻɑ:/ðəɻ	rɑ/ðər
99.	kʰowt	kot
100.	sɛ/lə/bɻey/šən	sɛ/lə/bre/šən